SCIENTIFIC AMERICAN

No. SUPPLEMENT 738

Scientific American Supplement, Vol. XXIX. No. 738. Scientific American, established 1845.

NEW YORK, FEBRUARY 22, 1890.

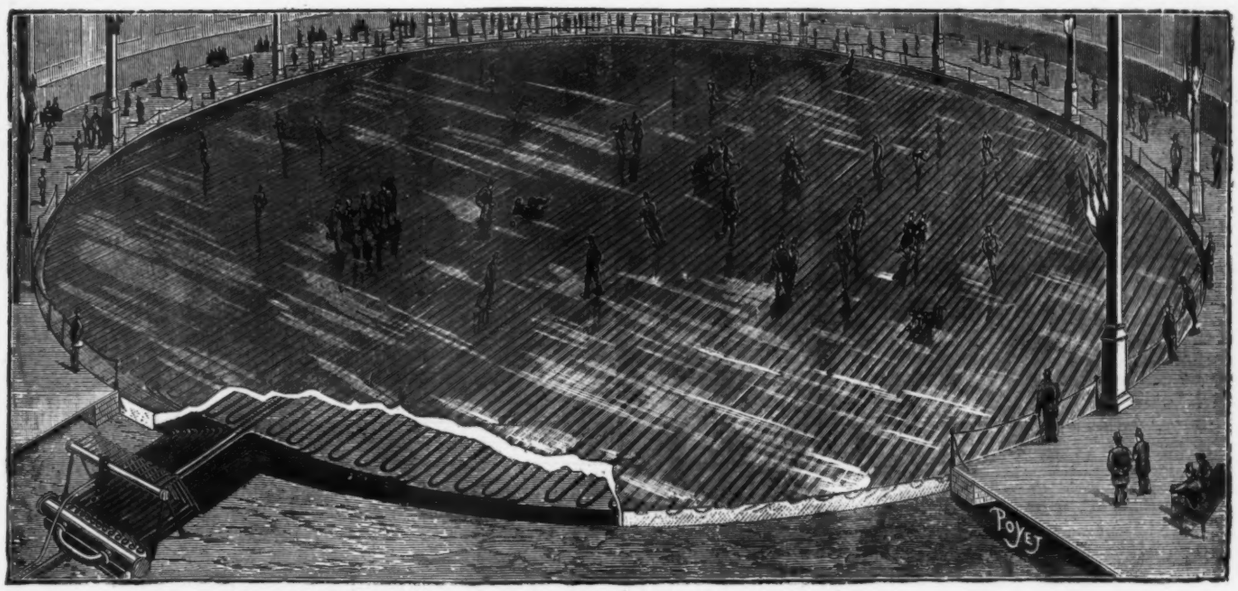
Scientific American Supplement, $5 a year. Scientific American and Supplement, $7 a year.

THE PERGOLESE STREET SKATING RINK, PARIS.

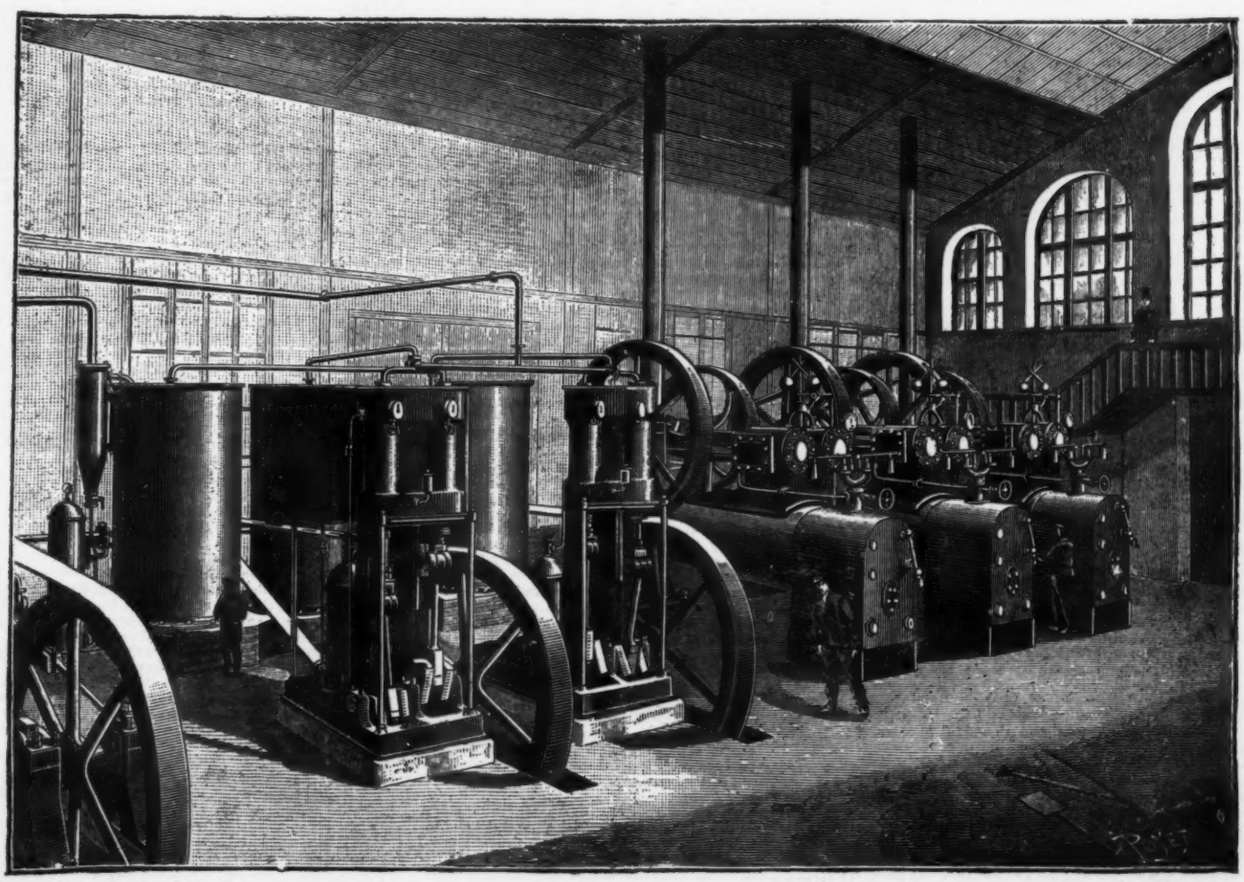
THE *Gran Plaza de Toros*, of Pergolese Street, after enticing entire Paris to it through its bull fights, is again upon the point of attracting the curiosity of Parisians by its natural ice skating rink. With very rare exceptions, the climate of Paris scarcely admits of the pastime of skating, and we have all observed that every time that the Skating Club has announced a fete for the next day a thaw has intervened, skates have passed to the state of emblem, and the ice has become a myth. And yet those whom the sport interests are numerous. You can now rejoice, amateurs of skating, for, whatever be the height of the temperature, you will be able to indulge in your favorite exercise. Thanks to the resources of modern science, the Plaza is to be converted into a mirror of hard and polished ice.

The earth, still red with the blood of bulls, has been excavated, and a basin of beton has replaced the sand that witnessed the exploits of Lagartijo, Guerrita, and others. Fifty-two thousand feet of iron pipes have been connected, bent, and placed upon this new foundation. These are designed to carry the cold to the eighty-two hundred superficial feet of water contained in the basin, to a depth of seven inches. Three powerful steam engines, actuating three ice machines, compress the ammoniacal gas to liquefaction in order to inject it into these pipes and produce a temperature of 30° C. through expansion.

In a word, perfectly dry ammoniacal gas, compressed by powerful pumps and reduced to a liquid state, is



FREEZING APPARATUS OF THE PERGOLESE SKATING RINK, PARIS.



ENGINE ROOM OF THE PERGOLESE STREET SKATING RINK, PARIS.

forced into a series of pipes immersed in water. This liquid ammonia is converted into gas through expansion, and freezes the water. The gas is afterward sucked out by pumps, which again compress it, so that it serves indefinitely.

Shall we speak of the rink building, that masterpiece of carpentry, with its wooden trusses of 180 feet span? Since the Eiffel tower and the Frith of Forth bridge, nothing is impossible to the engineer.—*L'Illustration.*

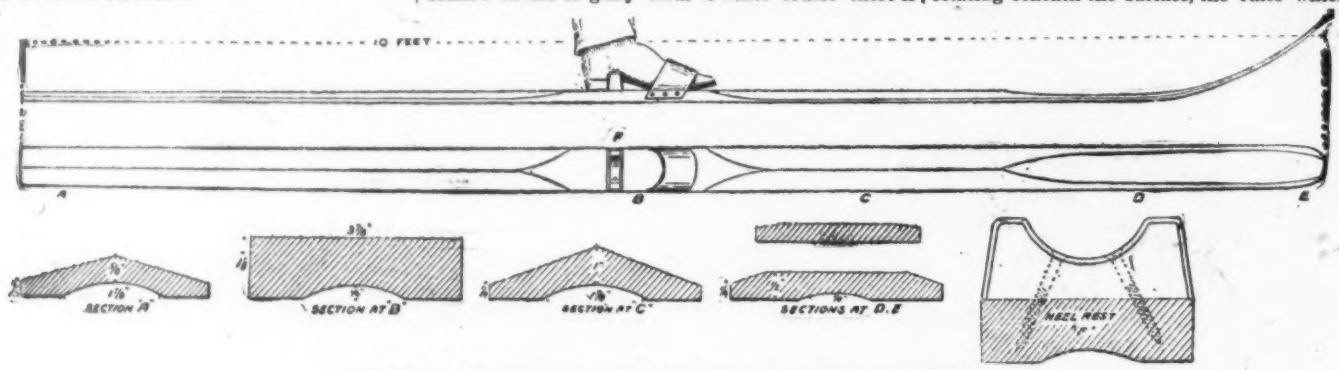
THE NORWEGIAN SKEE, OR SNOW SHOE.

FOR the original working drawing of a *skee* or Norwegian snow shoe, here presented, we are indebted to Mr. E. P. North, M. Am. Soc. C. E. Mr. North obtained it from Mr. John R. Gillis, a deceased member of the Am. Soc. C. E. and engineer of tunnels 1 and 2 on the Union Pacific Railroad.

Snow shoes of this description, and made on the model shown, were very generally used by the mail carriers in the mountain regions of California and Nevada before the advent of the railways, and also to a considerable extent by the engineers during the construction of the Central Pacific Railroad. Over undulating country, several of the mail carriers are credited with having made as much as eighty miles per day on these shoes, although this was a very unusual record.

The *skee* is very simple in its design and construction. The material used in the West was so-called black pine, for which the nearest substitute in the Eastern States is spruce and tamarack or hackmatack. The drawing explains itself as to dimensions. The groove in the under part is to facilitate steering and to enable the runner to travel along a side hill.

In use it differs widely from the more familiar Canadian snow shoe, which is a light frame of bent wood, interlaced with thongs of raw hide, hard twisted twine or deer sinews. The Canadian shoe, permitting the soft snow to pass through the meshes, must be lifted by the toe to a considerable height with each step, and the shoe dragged along on the snow as the leg is advanced. Hence a moccasin is an essential adjunct to the Canadian type. The *skee*, on the other hand, is slid over the snow, by means of the strap shown resting against the instep, and is never lifted from the snow except when a jump is to be made. As each shoe presents a bearing surface of over three square feet and is without openings for the snow to pass through, it is claimed that the Norwegian type is preferable to the Canadian for use in soft snow.



THE "SKEE," OR NORWEGIAN SNOW SHOE.

On account of its great length, ten feet, the *skee* is best adapted to use in comparatively smooth and undulating country, or through open woods. It is in going down hill that the greatest speed is attained, and a stout steering or brake pole is very necessary at such times to guide the line of travel and to check undue velocity. The drawing is presented as a curiosity in the line of "rapid transit," but the editors of this journal especially disclaim any liability for mishaps accompanying a first practical test of the possibilities of this Norwegian invention.—*Engineering News.*

[FROM THE AMERICAN LAW REVIEW.]

SURFACE WATERS.

I. Defined. II. Distinguished from Water Courses. III. Subterraneous and Percolating Waters. IV. Overflow to Water Courses. V. Stagnant Bodies. VI. Right to Appropriate. VII. Obstruction of Flow. 1. Common Law Doctrine. 2. Civil Law Rule. 3. Modified Doctrine. 4. English Rule. VIII. Drainage of Surface Waters. IX. Pollution of Surface and Percolating Waters.

I. DEFINED.—Surface waters are waters coming from a casual source—as rains or melting snows—and having only temporary flow, although following a well defined course when they do occur;[1] or are waters which ooze through the soil, or diffuse or spread themselves over its surface, forming bogs, swamps, and marshes, and having no defined channel.[2]

II. DISTINGUISHED FROM WATER COURSES.—In defining the requisites of a water course, the courts are all agreed that there must be a stream flowing in a particular direction, though it need not flow continually. It may sometimes be dry. It must flow in a definite channel having a bed, sides, or banks, and usually discharge itself into some other stream or body of water. It must be something more than a mere surface drainage over the entire tract of land, occasioned by unusual freshets or other extraordinary causes.[3] The courts are also unanimous in holding that where rain water flows down a natural depression without forming for itself a bed or channel, there is no water course, although at recurring seasons a large stream of water should flow.[4] In Gibbs v. Williams,[5] a depression which formed the natural drainage of a tract of land amounting from one thousand to twelve hundred acres ran through a city. It was from three to five feet in depth, and from thirty to fifty feet in width. Across it at one time the city built bridges. It was called by various witnesses a ravine, a draw, a depression. Several testified to having run a mowing machine up it, and grass grew throughout the greater part of its extent. There was no general cut in the soil caused by the flow of water; and it had not the sharp, distinct banks of a ravine. A large stream of water usually flowed down it after rains, but the court held notwithstanding that it was not a water course, and the waters so flowing were surface waters. Brewer, J., said: "For a water course there must be a channel, a bed to the stream, and not merely low land and a depression in the prairie over which the water flows. It matters not what the width or depth may be, a water course implies a distinct channel, a way cut and kept open by running waters, a passage whose appearance, different from that of the adjacent land, discloses to every eye, on a mere casual glance, the bed of a constant or frequent stream."[6] He quoted with approval the language of the United States Supreme Court in Howard v. Ingersoll[7] to the effect that the bed of a river is a natural object, not to be sought for merely by application of abstract rules, but as other natural objects are sought for and found; by examining the banks and ascertaining where the presence and the action of the water are so common and usual and so long continued as to mark upon the soil of the bed a character distinct from that of the banks, in respect to vegetation as well as in respect to the soil itself.

The rule requiring a defined channel with bed and banks is subject to a slight modification. If a stream, after flowing for some distance in a well defined channel, owing to the level character of the grounds spreads out over a wide space without any apparent banks, yet usually flows in a continuous current, and passes over the surface to the lands below, where it again forms itself into a well defined water course, it continues to be a water course throughout its whole length.[8] If, however, such stream, instead of reappearing in a body, had sunk into the soil, and no water remained to pass along except under the surface, it would have ceased to be a water course.[9]

On the question whether waters derived from rain and melting snow and flowing in a body down a well defined ravine or gully form a water course there is some diversity of opinion. In Shields v. Arndt,[10] the court said: "There must be water as well as land, and it must be a stream usually flowing in a particular direction. It need not flow continually, as many streams in this country are at times dry. There is a wide distinction, however, between a regular flowing stream of water, which at certain seasons is dried up, and one which in times of a freshet, or the melting of snow, descends from the mountain and inundates the country." The Wisconsin court follows the same rule. In Hoyt v. Hudson,[11] the court declared that the term "water course" does not include water flowing in hollows or ravines in land, which is the mere surface water, and is discharged through them from higher to lower levels, but which at times are destitute of water. Such hollows or ravines are not, in legal contemplation, water courses. This ruling was followed in a recent case,[12] and seems to be in keeping with the civil law.[13]

In Kansas, the courts have rendered decisions which support the opposite view. In Palmer v. Waddell,[14] the court said: "The rule that the owner of a tract of land may obstruct the flow of surface water across his land appears to and does have an exception, which is where surface water, having no definite source, is supplied from the falling rains and melting snow, from a hilly region or high bluffs, and owing to the natural formation of the surface of the ground is forced to seek an inlet through a gorge or ravine, and by its flow assumes a definite or natural channel and escapes through such channel regularly during the spring months of every year and in seasons of heavy rains; and such has always been the case so far as the memory of man runs."[15]

A Nevada case seems to support the Kansas decisions, although in that case,[16] the flow of the stream seems to have had a greater degree of permanence. Currant Creek was supplied at certain seasons of the year from springs having their rise and flow along its banks and beds, but mostly from the melting snow on the mountains. There was no regularity as to quantity of the water, the amount flowing differing with the seasons, and being dependent on the character of the weather during the preceding winter. After a cold winter, when deep snow had fallen, the water flowed in greater quantity and for a longer time than after an open winter with but little snow; hence the amount of water varied in summer—according to the testimony—from nothing to five thousand inches. The court held that, notwithstanding the irregular flow, the creek was a water course.

In a case in Minnesota,[17] it appeared that the municipal authorities graded a street across a ravine. The ravine was about three rods wide, and on either side was a hill fifteen or twenty feet high. In the bottom of the ravine was a well defined channel or water course from six to eight feet wide and four to five feet deep. This was the only and usual means of drainage of a considerable tract of country; but in the absence of rains or melting snow, it was usually dry. The city constructed a sewer which proved insufficient, and the result was that adjoining lands were flooded. The courts held that the rules applicable to surface waters could not be applied without considerable modification. They said: "We do not deem it necessary to determine whether this was a 'natural water course' or mere 'surface water;' the general common law doctrine that neither the retention nor repulsion of surface waters is an actionable injury must necessarily be modified in such cases. In a broken and bluffy region of country, like that of southeastern Minnesota adjacent to the Mississippi River and its tributaries, intersected by long, deep cavities or ravines, surrounded by high, steep hills or bluffs, down which large quantities of water from rain or melting snow rush with the rapidity of a torrent after attaining a volume of a small river, and usually following a well defined channel, it must be manifestly inappropriate and unjust to apply the rules of the common law applicable to surface water. In many respects such streams partake more of the nature of natural streams than of surface water, and must, at least to a certain extent, be governed by the same rules.

III. SUBTERRANEOUS AND PERCOLATING WATERS.—In the case of waters flowing underground and percolating beneath the surface, the rules which govern waters flowing on the surface are applicable so far as the circumstances will permit. Streams flowing in body underground and having a known and defined course are to be treated as water courses, but percolations spreading in every direction through the soil are deemed to be upon the same basis as surface waters.[18] In Acton v. Blundell,[19] Tindal, L. C. J., after prefacing his remarks with the statement that "the question agreed had been in substance this: whether the enjoyment of an underground spring is governed by the same rule of law as that which applies to and regulates a water-course flowing on the surface," said: "We think that the present case is not to be governed by the law which applies to rivers and flowing streams, but that it rather falls within that principle which gives to the owner of the soil all that lies beneath its surface; that the land immediately below is his property, whether it is solid rock or porous ground or venous earth, or part soil, part water; that the person who owns the surface may dig therein, and apply all that there is found to his own purposes at his free will and pleasure; and that if in the exercise of such right he intercepts or drains off the water collected from the underground springs in his neighbor's well, this inconvenience to his neighbor falls within the description of *damnum absque injuria*, which cannot become the ground of an action."

In a later case,[20] Pollock, L. C. B., referred to the distinction drawn between subterranean waters flowing in a body and waters percolating through the soil in the following language: "If the course of a subterranean stream were well known, as is the case with many which sink underground, pursue for a short space a subterraneous course, and then emerge again, it never could be contended that the owner of the soil under which the stream flowed could not maintain an action for the diversion of it, if it took place under such circumstances as would have enabled him to recover had the stream been wholly above ground."[21]

IV. OVERFLOW OF WATER COURSES.—Waters overflowing the banks of a stream, in consequence of the insufficiency of the natural channel to hold and carry off the same, have been held to be "surface waters" within the meaning of that term.[22] With the excep-

[1] Gibbs v. Williams, 25 Kan. 214; s. c. 37 Am. Rep. 241; Lessard v. Stram, 62 Wis. 112; 51 Am. Rep. 715; Hoyt v. Hudson, 27 Wis. 656.

[2] Schaefer v. Marthaler, 34 Minn. 487; s. c. 57 Am. Rep. 73.

[3] Hoyt v. Hudson, 27 Wis. 656; Lessard v. Stram, 62 Wis. 112; 51 Am. Rep. 715; Palmer v. Waddell, 22 Kan. 352; Gibbs v. Williams, 25 Kan. 210; 37 Am. Rep. 241; Barnes v. Sabron, 10 Nev. 217; Shields v. Arndt, 3 Green's Ch. (N. J.) 234; Bloodgood v. Ayers, 108 N. Y. 400; 2 Am. St. Rep. 443; Barkley v. Wilcox, 86 N. Y. 147; 40 Am. Rep. 519; Luther v. Winnisimmet Co. 63 Mass. (9 Cush.) 171; Swett v. Cutts, 50 N. H. 439; 9 Am. Rep. 276. See, also, Schlichter v. Phillipy, 97 Ind. 201.

[4] Ashley v. Wolcott, 65 Mass. (11 Cush.) 192; Hoyt v. Hudson, 27 Wis. 656; Lessard v. Stram, 62 Wis. 112; 51 Am. Rep. 241; Bowlsby v. Speer, 31 N. J. L. 351.

[5] 25 Kan. 210; 37 Am. Rep. 241.

[6] See, also, Jones v. Wabash, St. L. & P. Ry. Co., 18 Mo. App. 251.

[7] 55 U. S. (13 How. 427.)

[8] Gillett v. Johnson, 30 Conn. 180; Macomber v. Godfrey, 108 Mass. 219; 11 Am. Rep. 349.

[9] Broadbent v. Ramsbotham, 11 Exch. 602; Buffum v. Harris, 5 R. I. 243.

[10] 3 Green's Ch. (N. J.) 234.

[11] 27 Wis. 656; 51 Am. Rep. 715.

[12] Lessard v. Stram, 62 Wis. 112; 51 Am. Rep. 715.

[13] In a case in Scotland, where the civil law is paramount, Lord Monboddo said: "A *magnum* or *torrens* which has not a perpetual course is entirely *privati juris*, and, therefore, the heritor upon whose ground it is may make that use of it if he pleases." Mags. of Linlithgow v. Elphinstone, 5 Brown's Suppt. 935.

[14] 22 Kan. 352.

[15] Quoted with approval in Gibbs v. Williams, 25 Kan. 210.

[16] Barnes v. Sabron, 11 Nev. 217.

[17] McClure v. City of Redwing, 28 Minn. 186.

[18] Wheatley v. Baugh, 25 Pa. St. 528; Acton v. Bundell, 12 M. W. 324; Chasemore v. Richards, 7 H. L. Cas. 348; Bury v. Pope, 1 Cro. Eliz. 118; Greenleaf v. Francis, 35 Mass. (18 Pick.) 121.

[19] 12 M. & W. 324, 348.

[20] Dickson v. Grand Junc. Can. Co. 7 Exch. 300.

[21] See, also, Saddler v. Lee, 66 Ga. 45; s. c. 42 Am. Rep. 62.

[22] Taylor v. Fickas, 64 Ind. 167; McCormic v. Kansas City, St. J. & C. B. R. R. Co., 57 Mo. 433; 25 Am. Rep. 431; Abbott v. Kansas City, St. J. & C. B. R. R. Co., 83 Mo. 271; 53 Am. Rep. 581; Shane v. Kansas City, etc., R. R. Co. 71 Mo. 237; Am. Rep. 480.

tion of cases cited, there appear to be no American cases bearing upon the subject. And there is, so far as can be found, only one English case which has only an indirect bearing. In that case,[33] the riparian owners had, for the purpose of protecting their lands, placed fenders upon the banks of a stream, with the result that the waters were prevented from escaping across the country as they had been accustomed to do, and were thrown back upon the embankment of a canal which suffered injury. The court held that the fenders were an unwarrantable obstruction or diversion of the stream, and that the proprietors might be indicted for maintaining a public nuisance. The court also declared that no distinction could be made between the ordinary course of water flowing in a bounded channel at all usual seasons and the extraordinary course which its superabundant quantity has been accustomed to take at particular seasons. No good reason seems to exist for making a distinction between an erection placed upon the bank of a stream and one placed at a distance from the bank, and it would therefore appear that the American and English cases can scarcely be reconciled.

As soon, however, as the overflowed water regains the water course, it cannot, in any event, be any longer deemed surface water. In Iowa the court has held that if water left the banks of a well defined stream, flowed over adjoining lands for a short distance and was then stopped by an embankment and forced back into the stream above a culvert, they were not surface waters, but must in determining the sufficiency of the culvert be regarded in the same light as if they had continuously flowed in the stream.[34]

V. STANGANT BODIES.—A body of water forming a lake or pond, and having no outlet, is governed by the same rules as are water courses.[35] A body of water four and a quarter acres in extent, in a natural depression forming a basin, was fed solely by surface waters produced by rains and melting snows falling upon higher adjacent land, and running naturally into such basin. The greatest depth of water in the basin at the deepest place was, at an ordinary stage, five feet, and at the same stage its greatest depth on the line between the lands of the parties on whose grounds it was situated was two and nine-tenths feet. The character of the soil under the basin was such that it retained the water, so that the only waste was from evaporation, except during high water for six or eight weeks in the year, when it overflowed through a natural channel on the land of one of the parties. There was another natural channel, through which, during heavy rains, and when there was an accumulation of water on the high lands from melting snow, the water flowed into the basin. The lands adjoining had been occupied and farmed for thirty years, and the body of water had never, so far as known, been dry except at a time of extreme drought in the year 1864. In winter the water froze to the bottom, but by cutting through the ice and digging into the mud at the bottom, water for stock could be obtained. It was held that this body of water, though only supplied from waters coming into the basin over the surface of adjoining lands, from rains and melting snows, must be governed by the same rules as water courses, and that one of the owners on whose land it was situated could not drain it off without the land owner's consent.[36]

The court said: "It is somewhat strange that, so far as we are able to ascertain, there is no case reported which decides the rights, with respect to a body of water, of the different owners of the land on which it lies. The cases most nearly analogous are those relating to water courses. . . . When surface waters reach and become part of a natural water course they lose their characters as surface waters, and come under the rules governing water courses. . . . When they have ceased to spread and diffuse over the surface, or percolate through the soil; when they have lost their casual and vagrant character, and have reached and come to rest in a permanent mass or body, in a natural receptacle or reservoir, not spreading over or soaking into the soil, forming a mere bog or marsh, they cannot be regarded as surface waters any more than they can be after they have entered into a stream. The mass or body of water constituting a lake or pond is an advantage or element of value to the lands upon which nature has placed it, of the same kind as is the water course to the lands through which nature has caused it to flow. There is no reason which can be suggested why the stream should be the property of each on his own land, of all the lands through which it flows, and why one owner should not prevent its flow as nature caused it to flow upon the land of another, that is not equally applicable to a body of water like this; and none can be suggested why the rights of the owners of the lands upon which nature has placed it should not be equal to the rights in respect to a stream."

(To be continued.)

MARINE ENGINE GOVERNORS.*

By Mr. J. D. CHURCHILL.

THE writer does not propose to go into the mechanical question, but is more particularly desirous of bringing before your notice some facts connected with marine engine governors which may not have presented themselves to your minds; also to meet the objections sometimes raised to the detriment of governors, feeling confident that, if they were more thoroughly understood, they would be much more highly appreciated, and the frivolous objections sometimes raised would be appraised at their real value.

Judging by the writer's experience, which is far from limited, governors have rarely received the attention they deserve. They have a very considerable and direct bearing on, or connection with, the question of preventable damage and losses at sea; consequently, they ought to receive special attention from those interested. Where human life and enormous amounts of valuable property are at stake, it is the bounden duty of all concerned, whether owners or otherwise, to insist on every possible precaution being taken to minimize the risk; therefore, any appliance or arrangement which in any way tends to this desideratum demands careful and prompt consideration. Political economists tell us that every loss, whether of life or property, is a national loss, and is not confined to the individual.

It is not necessary for the writer to explain the mechanical details and action of his own velometers and governors, seeing that there are upward of 2,200 of them in use, which may be accepted as ample proof of their efficiency. The compound attachment is an arrangement actuated by the governor, by which all the cylinders may be controlled. If perfect governing is required, this should be fitted in all cases.

The writer's remarks refer solely to governors operated or driven by the main engines, as he considers all others are but very poor apologies and not entitled to the name of "governors," as they have only occasional control over the engines, not available in case of accident, whereas a real governor, properly fitted and worked, has continuous control over all the cylinders under all conditions and circumstances.

Governors are frequently fitted in positions most difficult, sometimes dangerous, to get at, giving the idea that they are not intended to be used, only viewed from a distance. Consequently they are not always kept in proper working condition, much less continuously at work, as they ought to be. This is not fair to the makers, and, unfortunately, they are not in a position to insist on proper fitting and location of the machine. A strong protest ought to be entered against governors being considered as only rough weather attachments. They are that and very much more. A governor is as much an integral part of an engine as a safety valve is an integral part of a boiler, or an automatic brake is of a train. The law compels you to fit these to prevent accident. For precisely the same reason it ought to be compulsory to fit a governor. A governor is, pre-eminently, a safety appliance, and not, as most people imagine, simply a machine to prevent racing. It is a safety appliance directly affecting, as it tends to prevent or minimize the effects of a breakdown, and possible loss of life and property at sea, and as such it ought to receive very special attention from those responsible for the lives of our sailors and passengers.

The machine ought to be so fitted as to be easily accessible from the starting platform, and so that whenever the engines are at work it shall be in operation. It ought not to be optional with, or even left to the discretion of, the engineer on watch to decide when it shall be put on, unless you can make it optional with him, or leave it to his discretion, when an accident shall happen. It is an automatic check in case of accident, and common sense and common humanity demand that it should be a permanent attachment and continuously at work.

A good governor, if properly fitted so as to control, at any rate, two out of the three cylinders, will prevent racing, but it is unreasonable to expect it properly to control a three or four cylinder engine when it only has hold of the high pressure cylinder, thus leaving two-thirds or three-fourths of the engine uncontrolled just at the most critical moment. If a governor and compound attachment are properly fitted to an engine, no matter how many cylinders it may have, it will be held under perfect control with full steam on, and the ship may be driven—so far as the engines are concerned, and without reference to those on deck—at full speed in the heaviest weather, and there will be no indication of racing.

It is in heavy weather, when the engines are subjected to violent shocks and stresses, caused by excessive and sudden variation of load, that the damage commences, but, owing to the engines being eased down, the beginning of an accident does not then appear. When the weather moderates the real danger of a breakdown arises, as full steam is then put on, stressing everything to its utmost, and then follows the collapse. Perhaps it has never occurred to many to notice when breakdowns take place. By far the largest proportion occur in fine weather, and not in rough weather. It is in fine weather that the engines are most severely pressed. If the shaft breaks, the engines will fly away at an unknown speed, and, before the engineer has time to think, much less to act, it is through the ship's side or bottom, or the stern is pretty well shaken off, in either case producing serious leaks, as in the case of the s.s. Danmark, where some 800 lives were in peril from this very cause. If a good governor properly fitted is continuously at work, the engines could not practically exceed their normal speed; thus the danger and damage would be reduced to a minimum in case of accident, as it would give the engineer in charge a chance to stop the engines before much damage could be done.

The injurious effects of racing are felt throughout the whole engine and its fittings, and the author cannot do better than quote the words of a well known writer on this subject, Mr. T. G. Barron, who speaks from long practical experience at sea. He says: "When an engine attains suddenly a speed of double the number of revolutions per minute at which it is intended to run, and is as suddenly brought up to its normal rate, it may be said to be racing, although very much worse racing than this is common enough; and the whole strain of the sudden check to the engines caused by the extra resistance offered by the water to the propeller as it dips, after being partially or wholly lifted out of the water, must necessarily be transmitted through the whole length of shafting and coupling bolts from the propeller shaft to the crank shaft. If the governor is quick enough to check the racing before the propeller is again immersed, the twisting strain to the shafting will be avoided, or at least greatly reduced.

"There is also a severe straining to the pumps, pump rods, and links, caused by the racing, the pumps being unable to deliver the water quickly enough; and the bucket valves coming down heavily on the surface of the water put extra weight on the rods and other gear, as well as destroying the valves. The feed pumps being only partially filled with water, and the rams coming suddenly in contact with it, give a shock to the barrels of the pumps, and also to the pump crosshead, etc., which is not the case when running at their normal rate. A continuance of this vibration loosens the foundation plate of the engine, and in fact it would be difficult to say where the evil of racing ends, and it is only necessary for the shipowner to know a small portion of it, in order to see the benefit of a thoroughly efficient governor."

Only quite recently we have had reports of serious damage having been done by racing to the pump valves, condenser doors, etc. In one case the condenser doors were cracked, and the main steam pipe caused to leak, necessitating the stoppage of the ship at sea for repairs, generally a very difficult and dangerous operation. Among other very serious results of racing is the loosening and frequent fracture of the stern tube and bush, and damage to the hull caused by excessive vibration; also the great alarm it causes on board passenger steamships, a serious consideration, though it has neither a mechanical nor economical bearing. There is also the prejudicial effect of vibration, such as that produced by racing, on the chronometers and compasses.

This is confirmed by the leading makers of these instruments. If an ungoverned engine gets away, which it may easily do, to three or four times its normal speed, it will cause considerable agitation of the water in the boiler, materially facilitating, if not actually causing, priming, especially in boilers so inclined, thereby incurring the risk of serious damages in the steam pipes by water hammering, and breakages in the cylinders. The condenser is liable to become overheated, owing to the circulating pumps not working efficiently at racing speeds, causing partial or total loss of vacuum when the full power of the engines is required, danger of leakage, and breakdown of condenser through undue expansion and contraction. These difficulties can only be overcome either by throttling (wire drawing) the steam, or else linking the engines up, in both of which cases there is a material loss of power and speed, which can almost entirely be avoided by the use of a proper governor.

It is sometimes stated that even if triple engines do race, it is not as objectionable as with two-crank engines. Such a remark can only apply to one's personal comfort, as acceleration of speed means a considerable increase of wear and tear. All experience proves that under similar conditions a three-crank engine will get away more quickly, and run at a higher speed, than one with two cranks. Granted the three-crank may run more smoothly than a two-crank, and its racing, therefore, would not be so uncomfortably perceptible; but all other objections and risks remain, and, if anything, are increased.

While compound engines were in vogue, there was hardly an engineer but who insisted on having them fitted with reliable governors; but since the introduction of the triple compound engine, an idea seems to have got abroad that they do not require governors—why or wherefore it is difficult to explain. There is no doubt that the late low prices and keen competition have considerably militated against governors; and the writer cannot but think it is a "penny wise and pound foolish" policy to cut them out of the specification. A paltry saving of a few pounds as compared with the value of human life, and the jeopardizing of such enormous interests, seems a parsimonious course.

Some engineers maintain that triple expansion engines, "being so well balanced," do not require governors. Now it appears to the writer that this is an idea that has been adopted without due consideration, and he hopes to prove the argument untenable. So far as the writer can learn from these gentlemen, the balancing consists in the engines having three cranks, thus giving a more uniform turning moment to the crank-shaft than in the compound engine. No one will deny that the three cranks may balance each other, but there the balancing ends, for as soon as you get away from your cranks the unbalancing commences; first of all in the weights of the pistons, the low pressure being from four to six times the weight of the high pressure; then, secondly, there is frequently a very large discrepancy in the power developed by the respective cylinders, which fact seems to have escaped the notice of the disbelievers in governors.

Of course, this statement may be met with the remark that such ought not to be the case. It is admitted that it ought not to be, if it could be avoided, but it cannot be denied that through some cause or other this is invariably the case. The writer originally intended to have got together as large a number of indicator cards as possible, and from them to have worked out the indicated powers, but on further consideration it occurred to him that he might be charged with selecting only those cards which would support his line of argument. To avoid anything like a suspicion of this, he turned to the technical journals for information, for authoritative information, and there can be no question of incorrectness, the articles having been prepared by those who knew exactly what they were writing about, thoroughly competent men, who have undoubtedly presented to us the best phase possible of their respective engines.

The writer has referred to all the accounts he could find in these papers of the trial trips of a number of steamships fitted with triple compound engines, and finds that the discrepancy between the power developed by the cylinder doing most work and that doing least in any one engine is not less than 34·02 per cent. on the average. The analysis of these discrepancies is very interesting. On reading this paragraph over to an engineer, the writer was met with the reply: "The low pressure, generally indicates more than the high pressure because of the pumps." This led him to analyze the cases in question, with results as follows, which are scarcely in keeping with the explanation given.

H.P. is highest in	33	per cent.	of the cases.	
I.P.	"	16·66	"	"
L.P.	"	50	"	"

On further analyzing this the writer finds that the

H.P. is highest and	L.P.	is lowest in	33·33	per cent.	
Int.	"	"	H.P.	"	16·66 "
L.P.	"	"	H.P.	"	33·33 "
L.P.	"	"	Int.	"	16·66 "

These discrepancies, it must be borne in mind, have all appeared when the engines have been working under the most favorable conditions, and when in the hands of the most skillful men, working under the closest supervision of those interested in obtaining the best results. When these engines are put to their ordinary work, these discrepancies come out very much heavier. The best engine included in the group giving the above average only showed a discrepancy of a little

[33] Rex v. Tafford, 1 B. & A. 874.

[34] Sullens v. Chicago, R. I. & P. Ry. Co. (Iowa), 38 N. W. Rep. 545. See also, Moore v. Chicago, B. & Q. Ry. Co. (Iowa), 39 N. W. Rep. 36.

[35] Schaefer v. Marthaler, 34 Minn. 487; 57 Am. Rep. 75; Alcorn v. Sadler (Miss.), 5 So. Rep. 694.

[36] Schaefer v. Marthaler, 34 Minn. 487; 56 Am. Rep. 73.

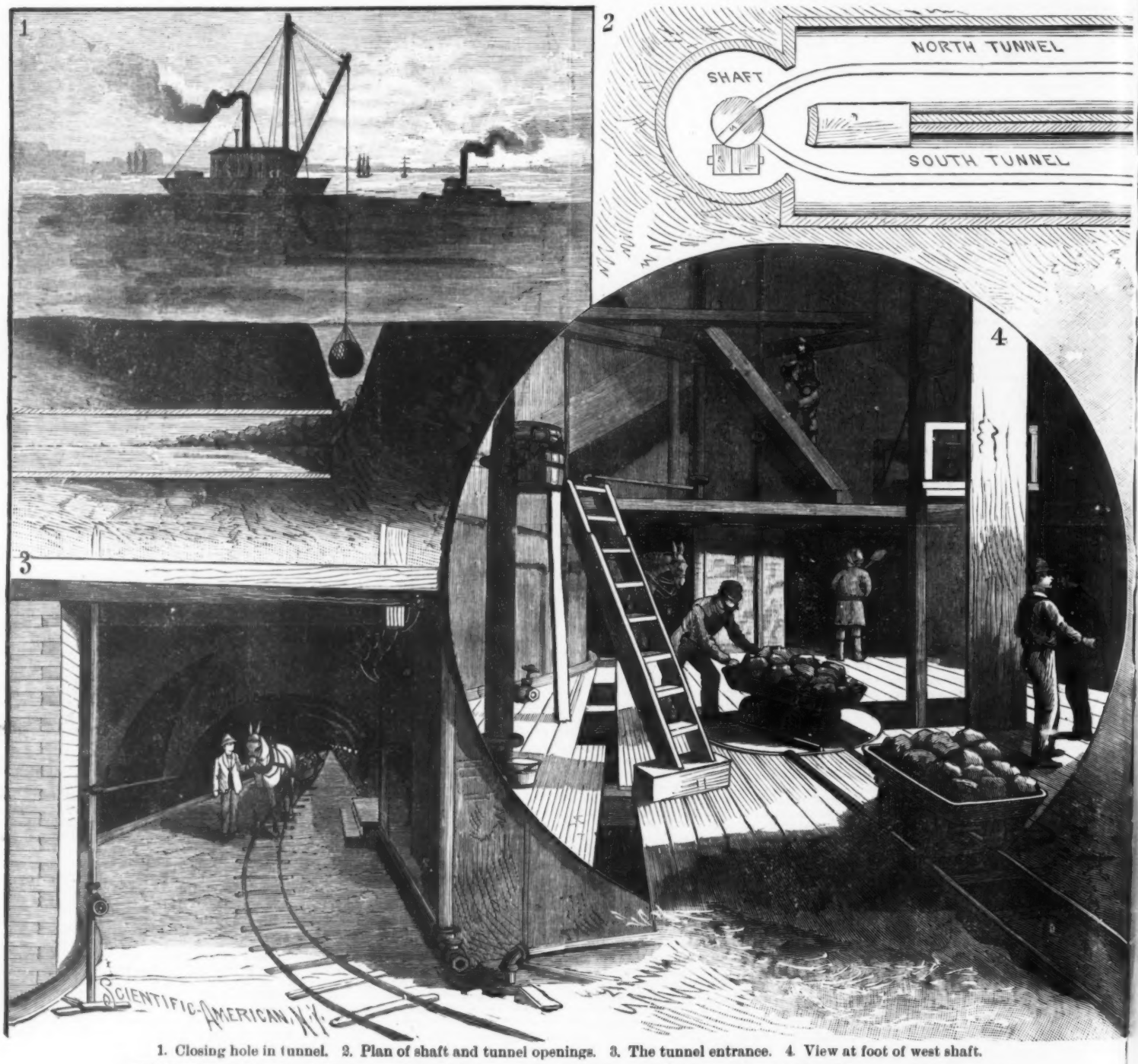
* Paper read before the Institution of Marine Engineers.

over 10 per cent. in the published report of her trial trip, but the writer has seen numbers of her cards under ordinary working conditions, and finds that the difference is never less than 23 per cent. In the trial trip reports 71·43 per cent. of the cases show a discrepancy of 25 per cent. and upward, and 21·42 per cent. show discrepancies of upward of 50 per cent. It is a remarkable fact that not one of the engines referred to in the reports on the trial trips is anywhere near being balanced, and some of them in ordinary work show more than double the difference indicated on the trial trip.

The writer considers the above figures pretty well dispose of the theory of perfect balancing, which is so frequently referred to in contravention of facts, and fully proves the fallacy of ignoring governors, on this ground, at any rate. Not long ago a friend of the writer's was in treaty with a well known engine builder for a pair of triple compound engines. When they came to the question of governor, the builder assured the intending purchaser that he built engines strong enough to stand any amount of racing. The writer, to convince his friend that the statement was not true, took the trouble to hunt up the breakdowns of engines built by these particular builders. It is certain they would not like the writer to reply to their *ad captandum* statement by publishing the list, which contains a good round "baker's dozen" within a very short period.

During the last eighteen months the writer has received particulars of 217 accidents to cranks, screw shafts, and propellers at sea. This number is exclusive of fractures and other defects found out in port and repaired. Out of the number 127 were broken shafts, in every one of which the safety of the ship and the lives of the crew and passengers were more or less imperiled. The cases referred to, doubtless, only form a minor portion of the total accidents. Besides these, there are numbers of screw steamers missing every year with all on board, and the writer is supported by competent authorities in the opinion that the major, or at any rate a very large, portion of these have gone to the bottom through accidents similar to that which occurred to the s.s. Danmark, where the broken shaft pounded a hole through her bottom. Doubtless, all have heard of many very narrow escapes from similar causes, in which they have only just had time to get the bulkhead doors closed and so save the ship.

It is hoped that the facts set forth in this paper prove the necessity of having a thoroughly efficient governor, properly fitted, and continuously running. Of course, it is impossible for a governor to prevent breakdowns, but when they unfortunately occur the effects are minimized. The following is an extract from a letter received from a well known engineer: "The non-fitting of a governor is a piece of culpable negligence;" expressing an opinion in which all interested in steamships should fully concur. The writer trusts he has succeeded in bringing forward and establishing many reasons why governors should be fitted. Many of these reasons he has never heard referred to in discussing the question, and can only conclude that they are not generally known. If these facts cause governors to be considered as necessary permanent attachments for marine engines, he will feel that his work in preparing this paper on "Marine Engine Governors—beneficially considered," has not been spent in vain, and trusts the future will prove that he has, if only in a small degree, contributed something to the comfort and safety of those at sea.



1. Closing hole in tunnel. 2. Plan of shaft and tunnel openings. 3. The tunnel entrance. 4. View at foot of west shaft.

THE HUDSON RIVER TUNNEL AND THE WORK IN PROGRESS UPON IT.

THE HUDSON RIVER TUNNEL.

THE Hudson River tunnel, designed to give passage for railway trains under the wide body of water that separates New York from Jersey City, is again in process of construction. Some twenty years have elapsed since it was proposed in its present shape by the eminent engineer Mr. D. C. Haskin. It is the property of the Hudson Tunnel Railroad Company, a corporation organized under general laws of the States of New Jersey and New York, but which laws were passed for its benefit. It has a capital stock and has issued bonds to the amount of ten millions of dollars each. Were it now completed, there would be some 300 trains each way that would pass through it every day. For telegraphic cables, pneumatic tubes, and similar purposes, its uses would be of considerable extent. The construction of other tunnels to the north and south of the present work is in contemplation also.

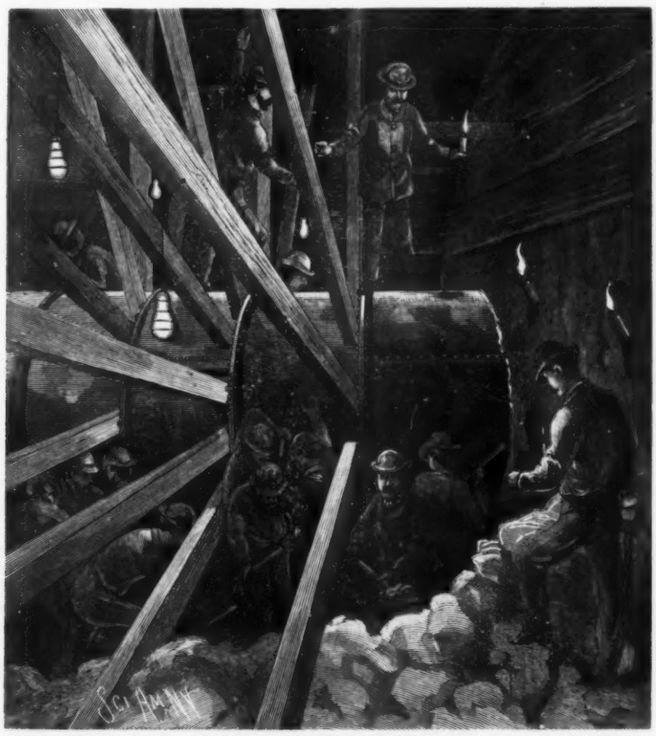
A year was occupied in taking a most exhaustive series of borings all along the proposed line of the tunnel across the Hudson River. These determined the fact that a bed of silt, admirably adapted for the work, extended most of the distance. In November, 1874, active work began on the New Jersey shore, under the general railroad laws. A month later an injunction arrested its progress, and for nearly five years nothing was done. It was in this interval that the passage of the special laws alluded to was obtained. Work began again in September, 1879, and all went smoothly forward. In the SCIENTIFIC AMERICAN of May 8, 1880, will be found an illustrated article on the operations of that early period. On July 21, 1880, an accident happened, in which twenty men were shut up in the tunnel and perished, the tunnel being flooded with water and partly collapsed. This occasioned more delay, which was to be regretted, independent of the dreadful loss of life and the popular stigma which it tended to place upon the tunnel. With much difficulty the damage was repaired and the bodies of the unfortunate men were recovered. Again, on November 4, 1882, work was stopped on account of the fatal illness of the president of the company, Mr. T. W. Park, and was not resumed for want of money. Up to this time about $1,050,000 had been expended, not counting interest or private expenditures of the originator of the tunnel, Mr. D. C. Haskin. Recently new capital has been subscribed, largely by English capitalists. Within the last few months the tunnel has been pumped out and work recommenced. Three weeks of regular construction have advanced the north tunnel nearly fifty feet beyond the point reached in 1882.

The tunnel is built under the plans of Mr. D. C. Haskin. Vertical shafts were sunk near the shores of the river. The one on the west shore is sixty-five feet deep, circular in section, and thirty feet in internal diameter. The walls lining it are four feet in thickness. From these as starting points two tunnels commence, diverging slightly and coming later into parallelism with each other. Each tunnel is lined with a shell of steel, built up of plates secured at the joints by angle irons projecting inward. The steel is three-sixteenths thick

as at present used. Within this shell a brick lining is placed, of the best brick, laid in hydraulic cement mortar. The brick lining is two and one-half feet thick. The tunnels were started by pneumatic process, and the work is now prosecuted under air pressure. In general terms a bulkhead is established at some point in the tunnel near the outer end. Through this an air lock extends, and a constant air pressure is maintained there. The workmen find in front of them a face of silt to cut through. It is cut out by shovels and is removed by small tram cars, beginning at the top. As fast as removed, the plates of the outer shell are brought forward and bolted to the anterior course, and thus as the silt is removed the plates are put in place, until a complete circle is formed. As fast as a series of circles are finished the brickwork is put in, and the tunnel is complete to that point. To still further prevent air leakage, the brick is treated with a surface wash or thin coating of cement mortar.

This in brief is the plan originated by Mr. Haskin, and now followed, and concerning which much debate was carried on by engineers at the time of its first suggestion. It is essential that a proper material should exist to form the heading, or else special methods have to be adopted. Outlined above, the plan is given in its essentials only.

The present tunnels are in internal dimensions eighteen feet high and sixteen wide, and of oval section. The grade of the tunnel is determined by the limitation of a maintenance of at least fifteen feet of earth between the bed of the river and the top of the tunnel. Its line begins in Jersey City on Jersey Avenue and 15th St., running east to Hudson St. Here it begins to curve to the extent of 5° to the northward in its entire course from this point to the New York City bulkhead line at the foot of Morton St. Thence the line tends slightly to the south and extends to



WORK AT THE HEADING OF TUNNEL AND VIEW OF PILOT.

Broadway. The distance from the western terminus to Hudson St. is 3,400 feet, thence to the foot of Morton St. 5,500 feet, and thence 4,000 feet to the eastern terminus. Of course some of the terminal figures may be slightly modified.

On the New York side, work has been begun upon both the north and south tunnels; at present no work is in progress there, the north tunnel being advanced about one hundred and fifty feet, and the south tunnel being barely commenced. On the New Jersey side, the north tunnel was advanced 1,845 feet, and the south tunnel nearly 600 feet, when work was suspended, seven years ago. At the present time nearly fifty feet have been added to the north tunnel, and at a very early day work will be prosecuted in the four headings simultaneously.

In the north tunnel, on the New Jersey side, two air locks are used. About 1,200 feet from the entrance a bulkhead of brick four feet thick is built. This is braced by diagonal timbers, so as to make it exceedingly strong. Through this a cylinder of heavy sheet iron, sixteen feet long and six feet in diameter, is carried. It is provided with two doors, both opening toward the heading. Plate glass windows in the ends admit of communication by exhibition of written messages. This constitutes the first air lock, and in front of it a pressure of air of about twenty-five pounds to the square inch is maintained. A short distance back of the heading is the second bulkhead with its air lock. It is deemed essential that this bulkhead shall be close to the work. In front of it the pressure is kept at 32 to 34 pounds. The two locks make it much easier to enter than in the generality of caissons, where the full change of pressure has to be undergone in one lock.

On entering the tunnel from the shaft it is found to be about two-thirds filled with silt. On this a narrow gauge tramway is laid, which is continued through the air locks. The tunnel is kept filled to this extent, the removal of this portion of the excavated ground being left to the last. On passing through the last air lock the vertical face of silt is seen. This is a clay-like substance, of the consistency of putty, and, as the engineers put it, holds water and air. It possesses so much cohesion that, supported by the air pressure, it excludes water perfectly.

Here the men are seen cutting it away in stopes, putting the iron plates in position and laying brick. The tramway is used for removing the silt and bringing in the material. Each row of plates is called a ring, and four rings constitute a section, which is ten feet long. The bricklayers work directly behind the plate layers, the former beginning their work at the invert, generally working the length of one section. The average of progress of the finished tunnel is three feet a day, but greater progress will soon be made.

In advance of the large tube a smaller one called the pilot tube is carried. This is made of ¼ inch iron plates and is but 6 feet in diameter. It is carried from 30 to 60 feet in advance of the main tunnel. The radial braces are supported by it, which support the plates of the main tunnel tube while being put in place. The pilot gives the ground a thorough exploration, and enables any weak spots to be more easily guarded than if the main tube was at once advanced. It effects other important results, such as the prevention of slides, and is an indispensable adjunct to the work.

Before any of the new work had been finished, operations were delayed by a large hole where the river bottom had caved into the end of the tunnel. This was overcome by a very ingenious method. An old sail was procured and placed upon a rough network, made of old wire rope, etc. A quantity of loose hay, brick, and stones was placed in its center, and around the heap a wall of bales of hay, two high, was carried. The pit this formed being filled, the sail was gathered together and the netting was carried over its top, and the whole was brought into a roughly globular shape, about ten feet in diameter and weighing twenty-five or thirty tons. It was hoisted by a floating derrick, and lowered at slack water into the hole. Upon it a quantity of hay and stones and other material, followed by three scow loads of earth, were deposited. This effectually stopped the leak, and the place is now well back of the heading.

The favorable nature of the material and the fact that the four headings are well started puts the tunnel in a position for rapid completion. For the north tunnel about 550 days will be required to carry it from shaft to shaft. For the south tunnel about 700 days are allowed. This is the work that presents the most serious difficulties. The terminal sections can be put in progress at any time. In New York very extensive plans for underground terminal and intermediate stations have been designed. In Jersey City the end of the cut leading to the tunnel is within easy reach of all the railroads terminating there. About $2,000,000 will be expended in completing the river section of the north and south tunnels.

TORPEDO BOAT WITH PETROLEUM FUEL.

OUR engraving illustrates a torpedo boat recently built by William Doxford & Sons, of Pallion Yard, Sunderland. Fig. 1 is a general view of the vessel, Fig. 2 is a longitudinal section, Fig. 3*a* deck plan, and Fig. 4*a* sectional plan. Figs. 5, 6, 7, 8, 9, 10 show the position of the machinery. Figs. 11 to 21 illustrate the boiler. Fig. 22, page 11790, is a diagram giving curves of speed, power, etc. It will be remembered that a preliminary trial of this boat was made at Portsmouth in the early part of the year. Since then, during a recent visit to the north, we have had an opportunity of seeing the boat under way upon a more extended trial made in the by no means placid waters of the Northumberland coast. A very complete series of progressive trials have been carried out, the results of which we are now enabled to lay before our readers, together with particulars of the vessel herself.

Our illustrations will show the character of the boat. She is 137 ft. long by 13 ft. 9 in. wide by 9 ft. 3 in. deep. She is built of galvanized mild steel, and is of exceptionally strong construction. As stated in our previous notice, the plating and general construction are so good that it is hard to believe the boat was not built on the Thames; a statement which, we believe, some of our north country friends took at the time as a very left-handed compliment. The cabin accommodation and machinery space is as shown. A point which may be mentioned in connection with the construction is that the bottom is double, forming a series of tanks, the positions of which are shown in Fig. 2. These are primarily intended to carry the liquid fuel, which forms the most striking feature in the design of the boat, but they can be used for water ballast. In either case they add greatly to the stability of the vessel. There are eight of these built-in tanks, which together will hold 13 82 tons of liquid fuel. The arrangement is such that any one tank can be pumped out separately, or the whole can be operated simultaneously. All are fitted with filling, air, and sounding pipes. The small Worthington pump shown in the stoke hold, which supplies the liquid fuel to the burners, is constructed for pumping oil from any craft alongside into these tanks or from one tank into another.

The conning tower, in which is fitted the steam steering gear, engine room telegraph, etc., is built of steel armored plates, strongly supported by hollow steel stanchions carried down to the ship's floors.

The stem of the boat is of cast steel, having projecting shelves for connecting to fore and aft keelsons, and is carefully supported for ramming. The bottom end is shaped and scarfed to take the forward keel plate. The stern frame is also steel, with large surfaces worked inside for firm connection with the whole of the boat. The rudder frame is of forged steel, plated with galvanized steel sheets on each side, and having the center space filled in with teak. The frames of the boat are of galvanized steel angles, 2½ in. by 1½ in. by $\frac{5}{8}$ in. and 21 in. apart. The floor plates are 9 in. deep by $\frac{5}{8}$ in. thick, and increase in depth, necessary for forming various seatings for engines and boilers. The fore and aft keelsons are formed of T bars 3 in. by 2½ in. by $\frac{7}{16}$ in., with flanged plates carefully fitted on butts, and all riveted to double reverse bars. Intercostal keelsons also extend right fore and aft, formed of solid flanged plates, riveted to the reverse frames. At the fore and aft ends these keelsons are worked out, and carefully connected with the shell and stern posts.

The plating, which presents a uniform and even surface, varies considerably in thickness according to the position occupied, and is single riveted at the edges, and double and treble riveted through the butt straps. The latter are properly shifted clear of one another. The thickest plates are those on the keel, the ram, and round the stern tube. There are eight water-tight bulkheads in the boat, and each compartment is fitted with either one or two ejectors, according as its capacity demands. The engines are of the triple compound type, with cylinders 15 in., 22 in. and 33½ in. in diameter by 18 in. stroke. The engines do not present any special features of novelty, but are good examples of torpedo boat machinery, the large bearing surfaces and well balanced parts, together with the lightness of the reciprocating parts, enabling them to be run at the high speed required. The arrangements for lubrication are very complete. Every working part excepting the reversing weighshaft, and the back end of the drag links, has a separate oil pipe leading to the front of the cylinders, where it terminates in a small sight cup and oil valve. The latter are fed from a continuous horizontal oil pipe running from end to end of the cylinders, which in turn communicates with an oil tank placed immediately under the deck. This tank is fitted with a cock, which enables the whole lubrication to be stopped by a single movement.

Each cylinder has a piston valve with deep packing rings and springs. The valve spindles are specially guarded against the pull and shove of the drag links. The pistons are of cast steel of the usual dished form, fitted with Ramsbottom packing rings, and have a clearance of $\frac{1}{8}$ in. at the top and $\frac{1}{4}$ in. at the bottom, with a view of economizing the steam to the greatest possible extent. The reversing links are of the double bar type, with solid pins forged on for receiving both the eccentric rod double eyes and the drag links. The connecting rod bottom ends are forged solid with the rectangular body of the rod, and afterward slotted through and fitted with bolts and nuts for adjustment.

Parson's white metal is used for the bearing surfaces. The bed plate is of cast steel, and consists of six thwart-ship girders of the box section and two fore and aft girders of H section. The thwart-ship girders are recessed to receive the main bearing brasses, which are half round on the bottom for the purpose of easy withdrawal. These brasses and their keeps are also cast steel lined with Parson's white brass, and are of a total length of 56½ in.

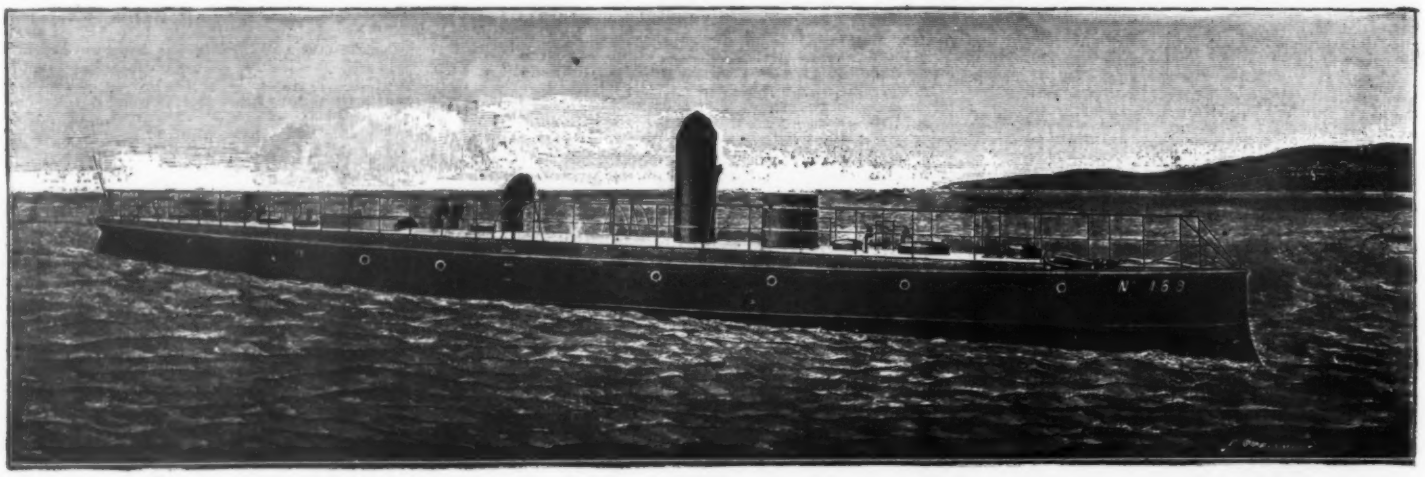
The crankshaft is in one piece of forged steel 5¼ in. diameter, with a 2 in. hole drilled through the crank pins, and 1½ in. hole drilled from end to end of the body of the shaft. It runs in Parson's white metal throughout. The eccentric sheaves and straps are of cast steel, the latter being lined with Parson's white brass.

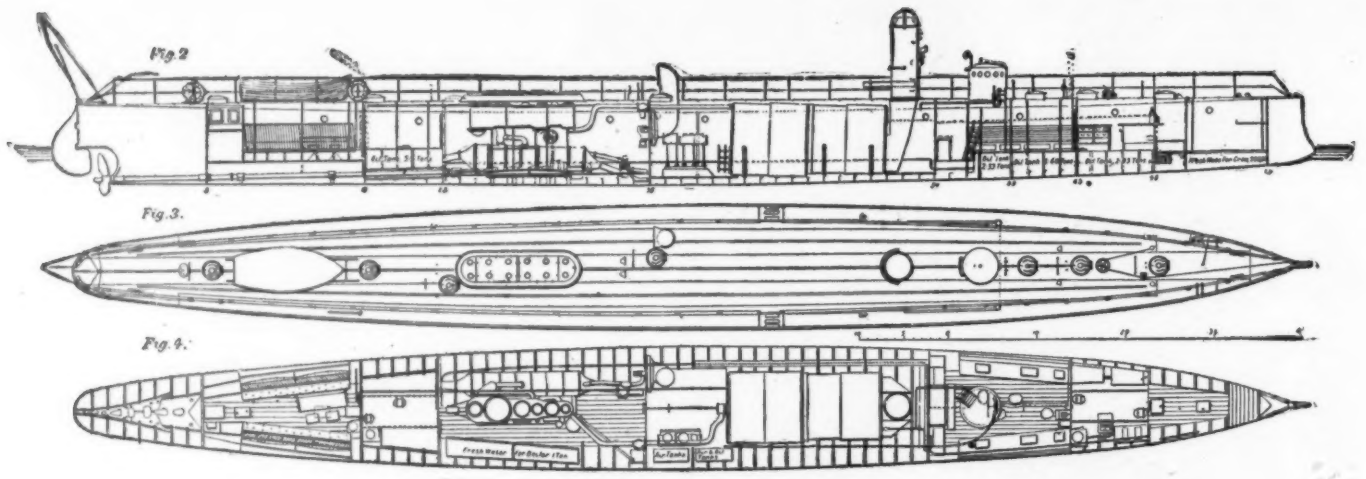
The air pump is single acting, 16½ in. in diameter and 6 in. in stroke, driven by levers and connecting rod from a crank forged solid on the fore end of the main crankshaft. It discharges its water into a hot well, from which it is in turn pumped by a Worthington type of feed pump into the boiler. The levers also drive a bilge pump 2½ in. in diameter and 6 in. stroke at one end of the air pump crosshead, and at the other a similar pump is used for circulating water through the guides of the main engine and other places.

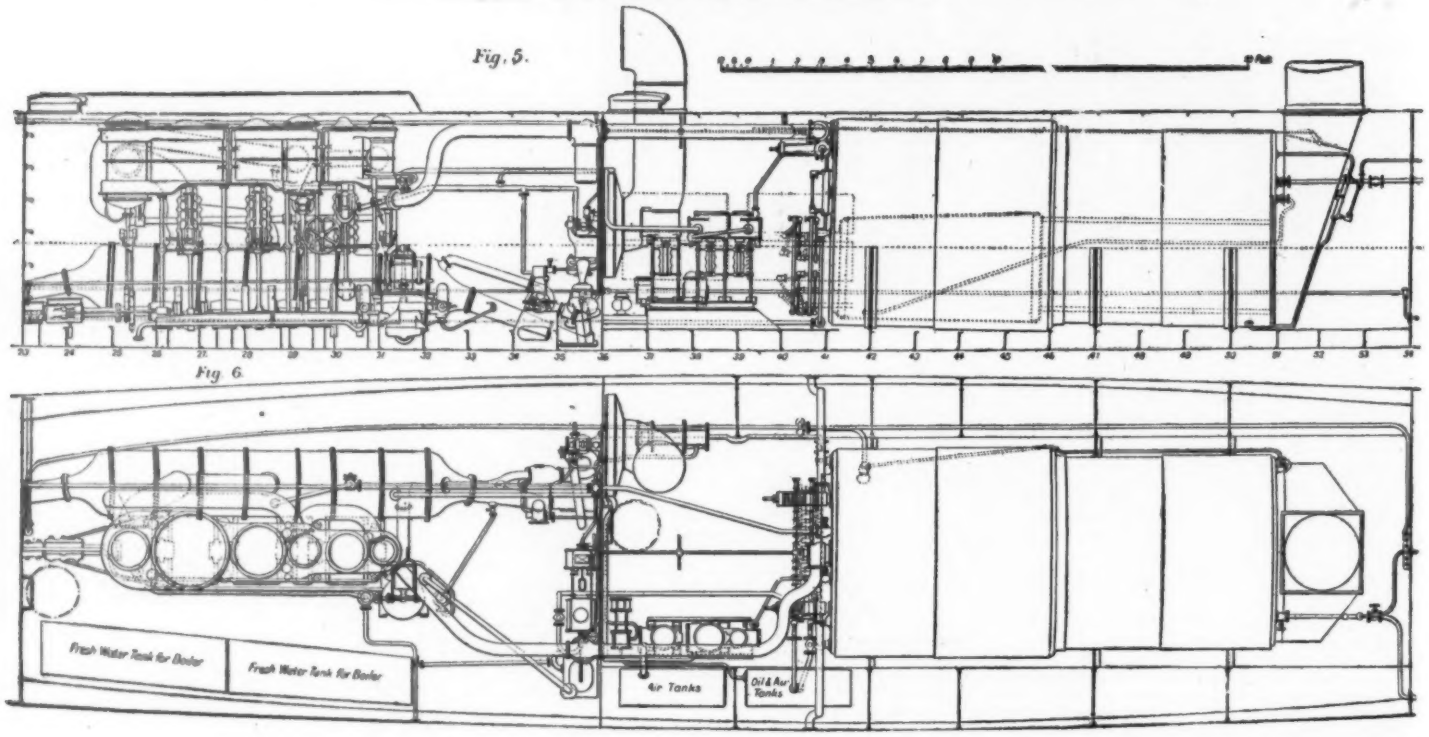
The condenser, which is placed at the back of the engines, is of sheet copper, and flanged in sections, these being bolted together with stiffening rings between the flanges, so as to readily resist the external pressure. It contains 1,745 square feet of cooling surface. The tubes, which are of brass, are 862 in number, and $\frac{5}{8}$ in. outside diameter. They are secured in the tube plates by screwed ferrules and cotton packing in such a way as to effectually prevent them becoming displaced. The condensation water is obtained by natural circulation, the quantity being regulated by injection and discharge valves on the outside of the boat. These valves are adjustable from the inside by screws and handwheels. These are peculiar in themselves, inasmuch as they open in such a way as to

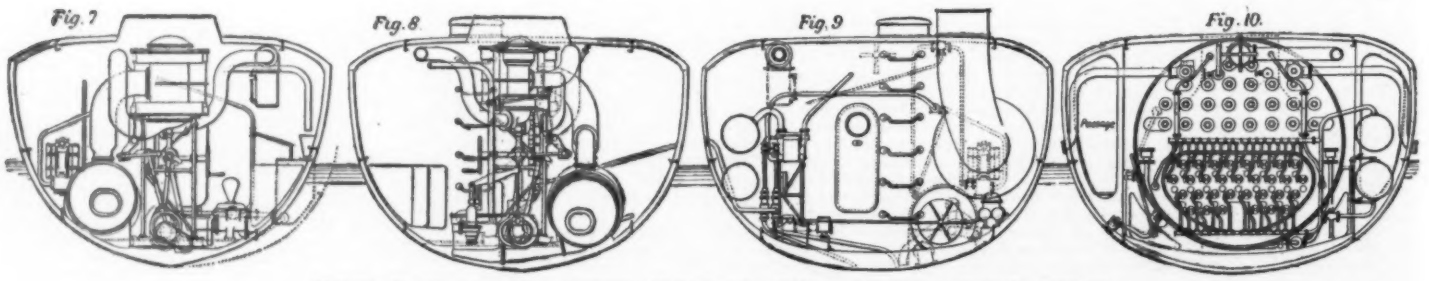
form scoops for collecting or discharging the water as the case may require, and also opening only to the extent necessary to collect or discharge that water, thus offering no more resistance to the forward motion of the boat than is necessary for circulating the water through the condenser. This is a great advantage over the ordinary fixed scoop. In addition there is a 4 in. centrifugal pump fitted for circulation.

The thrust block has a series of twelve rings all faced with Parson's white metal. Each ring has a separate sight cup and oil valve, similar to those already described on the front of the cylinders. The thrust is transmitted direct to the fore and aft girders of the main engine bed plate. It is in this way distributed over no fewer than five of the ship's ordinary floors, and seven special floors forming part of the attachment of the bed plate to the skin of the boat. It may be remarked that the whole of the boat's construction here is of solid flanged steel plates, not a single piece of angle bar existing in the whole of the engine seating. The only other attachment between the thrust block and the boat is one which communicates no more strain than that necessary to prevent the block turning with the shaft, the result being that there has been









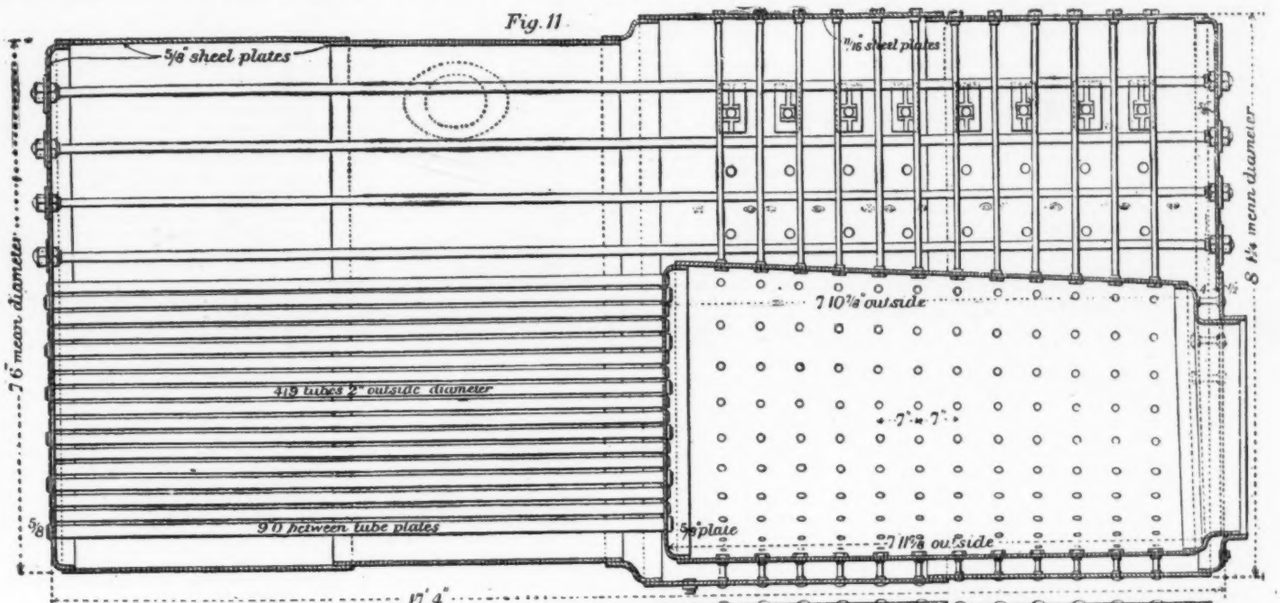
TORPEDO BOAT WITH BOILER FOR PETROLEUM FUEL.

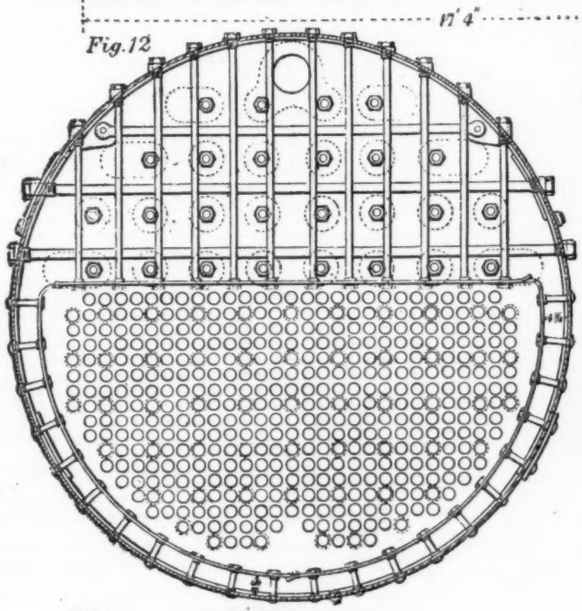
no sign of heating throughout the trials. The block accommodates itself to the slightest alteration of the shaft when forcing the boat through a heavy sea.

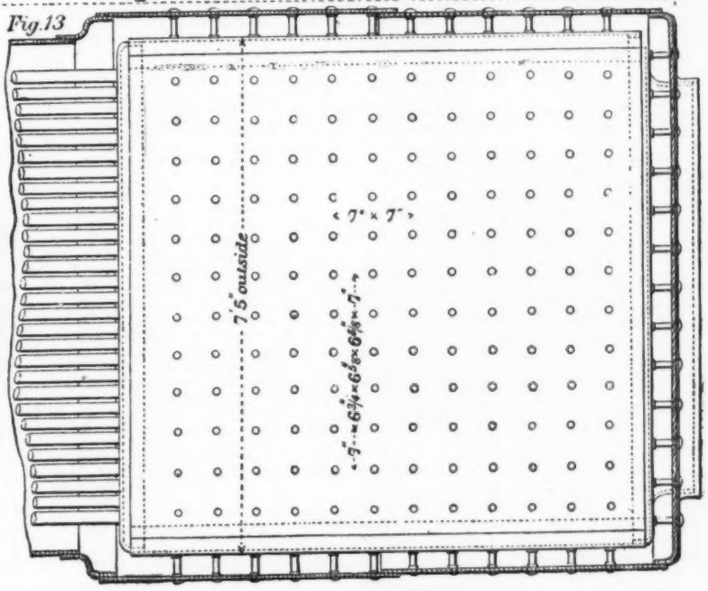
The propeller is 6 ft. in diameter, and 8 ft. 3 in. mean pitch, and is of solid cast steel. Each of the three blades are planed upon both their faces and their backs to an absolutely true and smooth surface and knife edge, and each blade is planed an exact counterpart of its neighbor, both in form and weight. This is effected by a planing machine designed by Messrs. Doxford for the purpose.

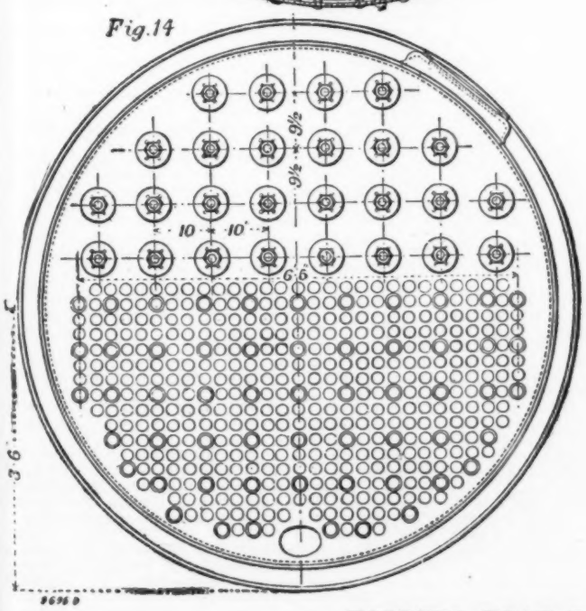
The boiler is of the ordinary locomotive type, having a wet furnace bottom, as shown. The furnace front is arranged to receive the oil burners, which are thirty-one in number. The boiler contains 419 tubes, 2 in. in diameter and 9 ft. long between the plates. The total heating surface of the boiler is 2,173·8 sq. ft., and the steam capacity is 305 cu. ft.

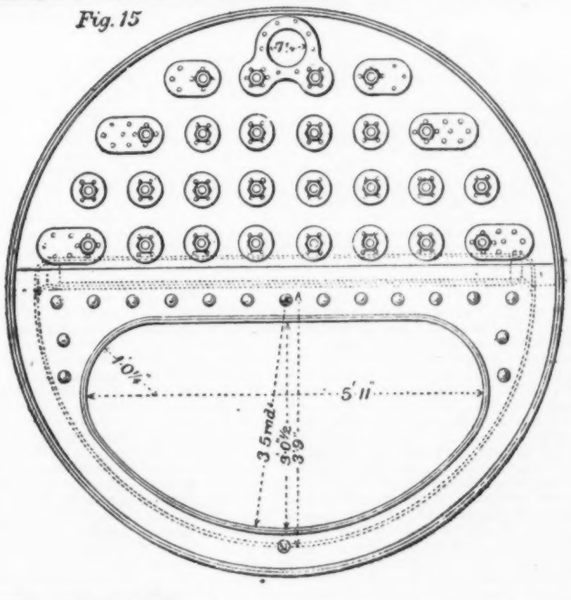
It is in the stokehold of this boat that the chief novelty lies. The liquid fuel used is pumped, by the small Worthington pump already referred to, from the double bottom of the boat, and discharged into a small cylindrical tank near the vessel's side, where it is subjected to an air pressure of 35 lb. per square inch, and from whence it flows direct to the burners. The stokehold also contains an air compressor, which discharges into cylindrical air tanks placed near the vessel's side, and forming a group of four, inclusive of the oil tank already referred to.* The working pressure of air in these tanks is 40 lb. per square inch, and it is conveyed here for the purpose of disintegrating the oil as it leaves the burners. Each jet of oil results in a clear, bright flame about 6 ft. 6 in. long and 9 in. in diameter if burning alone. When the jets are combined in the firebox, there results a bright mass of fire about 2 ft. from the furnace mouth to the tube plate. The flame entirely fills this portion of the furnace, and gives forth neither, smoke, smell, sparks, nor flame, so that neither soot nor dust is deposited in the tubes, and, therefore, no sweeping is required. Each burner can be made to consume from 25 lb. to 75 lb. of oil per hour, and each may either be shut off individually or











TORPEDO BOAT BOILER FOR PETROLEUM FUEL.

TRIAL DATA OF TORPEDO BOAT SUNDERLAND.

Number of run.	North or South.	Time.	Speed in Knots.	Mean Speed.	Indicated Horse Power.	Mean Indicated H. P.	Revolutions per Minute.	Mean Revolutions.	Slip per cent.	Displacement.	Displacement Coefficient. $\frac{S^3 \times D^2_3}{I.H.P.}$	Indicated Thrust in Lbs. $\frac{I.H.P. \times 33{,}000}{P \times R}$	Boiler Pressure, Lbs. per Square Inch.	Pressure in Steam Pipe.	Pressure in Intermediate Pressure Receiver.	Pressure in Low Pressure Receiver.	Vacuum.	Temperature of Feed Water.	Number of Burners at Work.	Compressed Air Pressure.	Oil Pressure.	Inches of Water Stokehold Air Pressure.
		m. s.								tons.			lb.	lb.	in.	in.	deg.		lb.	lb.	in.
1	N.	4 30	13·333	14·0435	244	232·5	303	305·0 15·869		86	232·4	4,536	148	40	10½ — 14	25	120	4	33	28	1¼
2	S.	4 4	14·754		321		307						160	42	13 — 13	24½	125	5	35	30	1¾
3	N.	3 57	15·190		486		350						157	70	28 — 3½	24½	130	6	35	30	1¾
4	S.	3 33½	16·862		439		345						153	70	28 — 4½	23½	125	6	35	30	1¾
5	N.	3 40½	16·327		652		373						157	95	30 1½ lb	24	125	9	35	30	3
6	S.	3 15½	18·414	17·3705	645	648·5	376	374 5 22·27		85½	156·58	9,450	159	96	41 2½ "	23¾	125	10	35	30	3½
7	N.	3 16	18·367		961		316						158	135	60 8 "	24	100	15	35	30	4¼
8	S.	2 54	20·600		977		316						158	135	60 8 "	24	100	17	35	30	4¾
9	S.	2 55	20·571	19·564	1001	973·5	324	316 0 23·955		84½	148·06	12,223	152	140	65 10 "	24	100	7	35	30	5
10	N.	3 14	18·537		946		308						148	140	63 9¼ "	23¾	100	17	35	30	5½
11	S.	2 40	22·500	21·0095	1220	1203·5	354	352 0 30·6		84	148·21	13,678	160	156	70 15 "	24	125	21	35	30	6¼
12	N.	3 4	19·565		1187		350						158	155	70 15 "	24	125	21	35	30	6¼

The speed of 21 knots was attained with the vessel carrying extra weight to the extent of 21 tons. Draught of vessel 4 ft. 2 in. aft, 3 ft. 10 in. forward, mean 4 ft. Displacement at 4 ft. draught 86·2 tons. Immersed midship area at 4 ft. aft, 40 sq. ft.

the whole collectively by the quarter turning of a pair of cocks, the operations being under the complete control of one man.

The usual fan for forced draught is fitted in the stokehold. A water pressure of 6½ in. is used with twenty-one burners, resulting, as will be seen from the table of particulars herewith given, and also the diagram, Fig. 22, in a speed of slightly over 21 knots and 1,203 horse power.

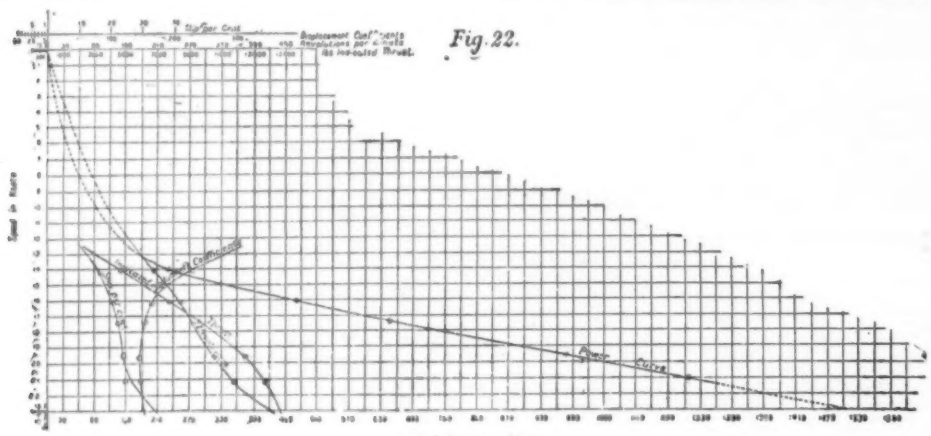


Fig. 22.

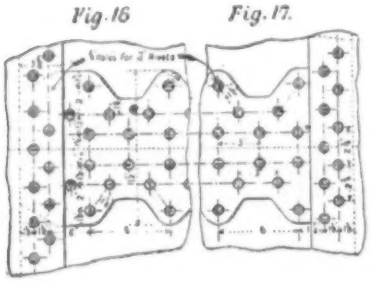


Fig. 16

Fig. 17.

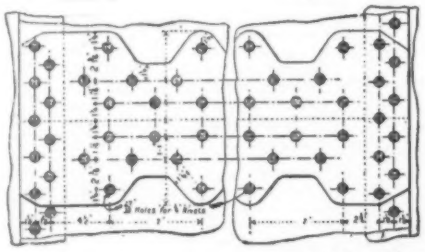


Fig 18.

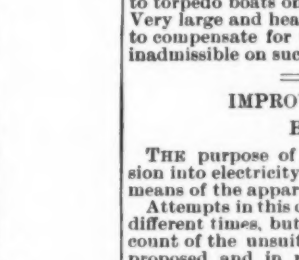


Fig. 19.

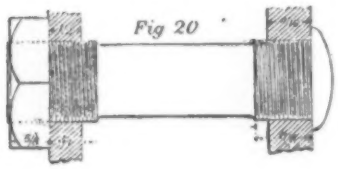


Fig 20

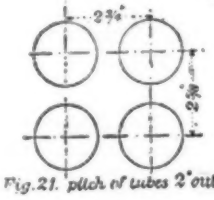


Fig. 21. pitch of tubes 2" outside diameter

One of the most noteworthy features is that the protection which the builders have found necessary to give the furnace plates from the high temperature of the furnace most effectually prevents leaky tubes and rivets. To illustrate to what extent this prevention of leakage applies, upon the occasion of a recent trial, made for the representatives of some foreign governments, the boat was driven at 21 knots per hour, and suddenly the engines were stopped. The fire, consisting of twenty-one burners, was shut off instantly, after which the steam did not rise enough to lift the safety valves. There was not the slightest sign of leakage of the tubes at the time, or of dampness in the furnace when it was examined on the following day.

In the course of experiments made to bring their system of oil burning to perfection, and since the final arrangements have been made, Messrs. Doxford have had a good deal of running with the vessel, some of it, by the bye, in very rough water. The boat has made one voyage to Portsmouth and home again to Sunderland in addition to the running about she has done in the North Sea. Through the courtesy of Messrs. Doxford we have been able to be present on some of the trials of this interesting vessel, and, so far as our experience goes, can fully confirm their statement that they have experienced no difficulty in the running of the boat since the arrangements have been perfected.

In the accompanying table we give data of some progressive trials made with this boat. In Fig. 22 these data are displayed in graphic form. From the figures quoted it will be seen that the boat attained a speed of 21·032 knots, with the development of 1,203 indicated horse power. The regularity of the power curve will be noticed in this diagram.

With regard to fuel consumption, Messrs. Doxford are, unfortunately, not able to give us very exact figures relating to recent trials. On one occasion, however, the boat was run for a considerable time at 20 knots speed, 1,001 indicated horse power being developed. The consumption was 1,001 lb. of heavy oil per hour. It is stated, however, that since these figures were ascertained modifications in the arrangement have led to greater economy, and it is anticipated that far more favorable results will be reached.

For the purposes of torpedo warfare the following are the advantages which are claimed by the advocates of the system of burning liquid fuel which we have here described.

First, there is the greater efficiency of this description of fuel, weight for weight, as compared with coal. This quality can be made use of either by carrying the same weight of fuel as would be carried were coal used, and so increasing the radius of action, or by retaining the same radius of action, and, in consequence of the less weight, being able to steam at greater speed. At 10 knots speed it is calculated that the boat would steam for a distance of 1,800 miles on her normal carrying capacity of fuel tanks, viz., 13·82 tons. It is usual, however, in torpedo boats, when making a passage to take extra coal in bags. Extra oil could be carried on this boat in casks.

The manner in which the fuel is stowed in the bottom of the boat allows of two important advantages being obtained, namely, increased stability and increase of available space. It is needless to emphasize the importance of the former in view of the recent overturning of the two French boats. With torpedo guns, torpedoes, machine guns, to say nothing of a number of men standing on deck, a torpedo boat is always apt to have a small reserve of stability. The low position of the center of gravity of the mass of oil in the tanks relieves this defect. The boat has considerably more stability with her tanks full than when empty; while filling the coal bunkers of an ordinary torpedo boat has a contrary effect. With regard to increased room put at the disposal of the designer by the liquid fuel system, the point is too obvious to need comment, and is very apparent when one goes on board the boat.

In maneuvering under steam it may be often desirable to stop suddenly and lay by for a greater or less time—perhaps a few minutes, perhaps an hour or more—and to be ready to go on at full speed at a second's notice. The difficulty of effecting this with a coal fire is well known to every engineer and naval officer. If the fire be kept at full capacity, with the fan running hard, it is difficult to get rid of the steam, in addition to which coal fires can only be kept in good order for a limited time. If a considerable portion of that time be spent in waiting for an opportunity to act, when the opportunity arrives the fire may be in such a bad condition that steam cannot be kept up. If, on the other hand, the fire be let down, it cannot be got into condition again until some time has elapsed. With liquid fuel, however, any number of burners may be put out of use instantly, and may be lit again as quickly. Thus, if the boat were running at a speed of 21 knots per hour, and were stopped suddenly, half or three-quarters of the burners could be put out, only sufficient being kept alight to maintain the steam at the maximum working pressure without lifting the safety valves. On the order being given to go ahead, the other burners would be lit and the pressure of steam thus maintained. In fact, it may be said that once steam reaches any required tension—maximum or otherwise—it may be kept at that tension so long as the fuel supply lasts, no matter whether the boat be kept running all the time, or whether she be intermittently stopped and started for any intervals, uncertain or otherwise.

The arrangement of the furnace is such that steam may be raised and lowered as suddenly as possible without causing leakage to the tubes or other parts of the boiler. In other respects the boiler is not subject to the well known causes of deterioration which are consequent upon using coal in a furnace. In fact, the life of the boiler ceases to be in this vessel a measure of the life of the boat. In most torpedo craft the boiler may be expected to give out first, and is the source of the greatest anxiety. With this system of firing such is not the case. It may be noticed in passing that in order to increase the durability of the engine, to bring it nearer to that of the boiler, increased bearing surfaces have been given to all rubbing parts. For the same reason adjustable bearings have been fitted to all parts, so as to take up in case of wear. In short, a higher efficiency of boiler with regard to durability has called forth a higher efficiency of engine (in the same respect) than has hitherto been considered necessary for such vessels.

With this system stokers are of course unnecessary. One man is more than sufficient to attend to the burners; he has nothing to do after the furnace is once put in operation. The fact that the system is automatic would doubtless be a great benefit in action. The advantage of not having to stoke, when steaming in a heavy sea, especially a beam sea, will be apparent. There is of course no coal trimming required, and the advantage of perfect cleanliness is obvious. The boat can be kept as clean on deck as a sailing yacht. The sweeping of the boiler tubes is not required.

In conclusion, Messrs. Doxford maintain that the system of liquid fuel burning which they have adopted is the only one applicable to torpedo boats. This is in the main due to the fact that air is used in place of steam for the injection of the fuel. There are many systems of steam injection, but they are not suitable to torpedo boats on account of the loss of boiler water. Very large and heavy evaporators would be required to compensate for this loss, and they would be quite inadmissible on such boats.—*Engineering.*

IMPROVED GAS BATTERY.

By PAUL SCHARF.

THE purpose of this invention is the direct conversion into electricity of the energy contained in gases by means of the apparatus described below.

Attempts in this direction have already been made at different times, but all unsuccessfully, in part on account of the unsuitable construction of the apparatus proposed and in part from the use of the gases in wrong proportions.

All gases or vapors may be applied in pairs, so that their reaction in a battery of suitable construction may yield an electric current. I use by preference either two gases, each belonging to one of the classes, *a* and *b*, or a gas and a liquid.

The gases may be: *a*, hydrogen, water gas, generator gas, coal gas, or all the vapors of the more or less volatile hydrocarbons of mineral oil, such as petroleum, gasoline, naphtha, etc.; and, on the other hand, *b*, air, oxygen, chlorine, fluorine, etc.

In the cases where I use a gas and a liquid, the one selected is used in place of a gas of the class *b*.

Hydrogen peroxide (H_2O_2) or nitric acid is suitable.

The above named gases of either or of both classes may (as described below) be used either in their natural state or compressed into a liquid, preferably water.

It is especially important that all the gases which I employ are not generated in my apparatus itself, but independently, according to any known or customary process.

Two gases having the properties above mentioned—*e. g.*, coal gas on the one hand and oxygen air on the other—are generated or stored separately. Each gas is then forced into a special holder—a pressure reservoir—in which a pressure of any required height can be maintained as nearly constant as possible. The pressure is given to the gases by any known apparatus, pumps, etc., and preferably direct. Each of the gases is then passed under pressure into the battery or current generator to be described below, where they remain at equal pressure, and still separated from each other by the electrodes.

The pressure may be strong enough to liquefy either or both gases, though this is not necessary for the result. Or the gases, or either of them, may be condensed in a liquid, such as water, and introduced into the cells.

Such a battery is shown in the accompanying figures, where Fig. 1 shows a longitudinal section, Fig. 2 an end view, and Fig. 3 a plan and section of a single electrode with its contact.

The apparatus consists of a holder, A, preferably of metal, and of any desired form. I have given it here, as the most suitable, a cylindrical form. The holder, A, is provided with a bottom or cover, A', A', by means of which it can be closed hermetically, either with screws or in any other known and suitable manner

In this holder, A, are the cells, formed each of two electrodes, *c*, the latter forming an interval. As electrodes, I use porous carbon in plates or any other form; here, *e. g.*, they have the form of disks to suit the receiver, A.

Each electrode, *c*, is inclosed by a metal ring, *d*, which is preferably (as shown in Fig. 3) provided at one part with a projection, d^1.

This ring serves exclusively for securing a good con-

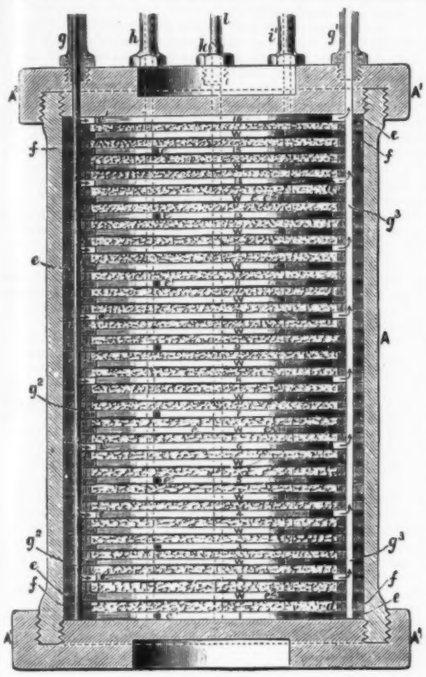


FIG. 1.

tact for conducting the electricity into the two polar wires, and can, therefore, be replaced by a piece of any other conductive material of any other convenient shape, which can be connected with the carbon.

Any oxidation or formation of salt at the surface of contact of the ring, *d*, or its substitutes, arising from the penetration of the reagents in the porous electrode, may be prevented by closing the pores near the surface of contact with paraffin.

In order to keep the electrodes, *c*, at suitable intervals of the formation of cells, there is placed between each two electrodes an insulation, *e*, of hard caoutchouc, pressed paper, or any other insulating mass, which must fit accurately and closely into the recipient, A. After prolonged experiments, I have succeeded in finding a mass which fulfills in the best manner both purposes of the rings, *e*, *i. e.*, insulation of the electrodes and rendering the recipient, A, compact. It is asbestos. I use rings moulded of asbestos, or cut out of plates which have already been employed for similar purposes. The electrodes, *c*, which with their rings, *d*, are smaller in diameter than the internal diameter of A, and are also surrounded by insulating rings, *f*, of hard caoutchouc, or preferably of asbestos, fitting closely on the insulating rings, *e*. As it may be seen from Fig. 1, a number of electrodes, with their metallic divisions and insulating rings, form a series of cells separated from each other. Every alternate interval, W, *i. e.*, the space between every two cells, is completely filled with a liquid conductor; for instance, acidulated water.

These intervals, instead of being filled with a liquid conductor, may contain porous non-conductive bodies,

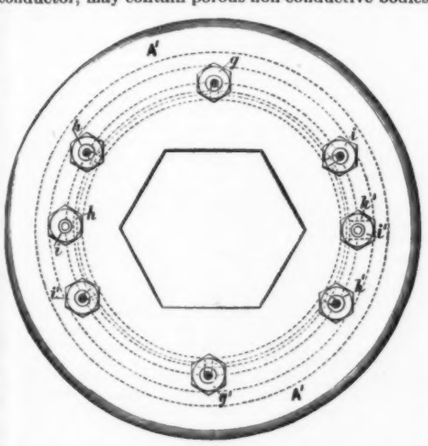


FIG. 2.

plates or disks in which the liquid conductor is absorbed, and thus effects a connection between the electrodes.

All the cells of even numbers 2, 4, 6, 8, etc., contain one gas, and the odd cells, 1, 3, 5, 7, etc., the other. All the electrodes which form cells for the same gas are in conductive connection with each other.

The introduction and removal of the gases and the water into and from the cells is effected as follows: The cover or one end of the recipient, A, is provided with eight apertures. Of these, g is the one gas inlet (*e. g.*, hydrogen) and g^1 the corresponding outflow; h is the other inflow for gas (*e. g.*, oxygen) and h^1 the corresponding outflow; i is the inflow and i^1 the efflux for the acidulated water.

At k and k^1 are the two negative and positive polar clamps corresponding to the apertures, g, g^1, h, h^1, k and k^1, all the insulating and tightening rings of the apparatus are provided with apertures which coincide with

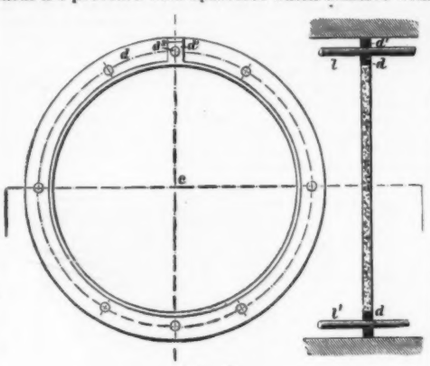


FIG. 3.

each other, so as to form the channels, g^2, g^3, h^2, h^3, etc., through which the gases of the acidulated water flow in or out. Each of the insulating rings, *e*, is traversed inwardly by one of the influx or efflux channels, or provided with a notch, e^1 or e^3, by which is effected a communication of the channel in question with the interior of the cell formed by the insulating ring affected. Each cell and each interval has thus an influx and an efflux aperture, e^1 and e^3. The hydrogen—*e. g.*, here employed—is introduced at g, passes through the channel, g^2, and enters the cells, 2, 4, 6, 8, etc., through the apertures, e^1, e^1, e^1. It fills the cells and passes out through the openings, e^3, e^3, e^3, into the exit channel, g^3, leaving the apparatus at g^1. Here, as at the other efflux openings, h^1 and i^1, a pressure valve must be applied in order to regulate the flow. As such valves are well known articles of trade, they need not be here described. The filling of the cells, 1, 3, 5, 7, with the other gas and that of the intervals, *w*, with acidulated water is also effected in the manner just described. The electric conduction to the poles, k, k^1, is effected as follows:

The projections, d^1, of the metal rings, *d*, or the connecting pieces in place of the latter, are perforated in such a manner that a metal rod, *l*, passes through each of these apertures, d^2, or rings, *d*, or through those of the substituted connecting pieces. The electric connection of the electrodes with the two polar clamps, k and k^1, is effected by means of the two metal rods, l, l^1, which proceed from the latter, pass through all the insulating rings in the apparatus, and are in contact with the corresponding electrodes by means of the projections, d^1, of the rings, *d*, through the openings of which they pass. The pressure at which the liquid conductor (*e. g.*, acidulated water) is passed into the intervals depends on the pressure of the gases in the cells; hence the influx and efflux of the water, as well as of the gases, must be regulated by valves.

The apparatus may be simplified as follows: Instead of using cells from which the gas passes into the electrodes, the electrodes themselves may be connected with the gas inlet in the apparatus, so that the gases pass direct into the pores of the electrodes, which thus, in connection with the liquid conductor, produce the same effect as that of the arrangement above described. The cells, 1, 2, 3, 4, 5, for the gases are thus dispensed with, while the position of the electrodes remains the same, since they are only separated by the intervals containing the liquid conductor.—*Zeitschrift fur Elektrotechnik.*

ELECTRO-AUTOMATIC REGULATOR FOR GAS.

THE object of the apparatus herewith illustrated is to automatically regulate the pressure of gas, whatever be the causes that make such pressure vary. The pressure at the works cannot, of course, be constant, but must vary at every instant according to the needs of consumption. Such needs are looked out for in advance; yet it sometimes happens that unexpected causes upset all calculations and the pressure suddenly increases or diminishes. It is for remedying this inconvenience that Mr. Petit has devised the apparatus which we are going to describe.

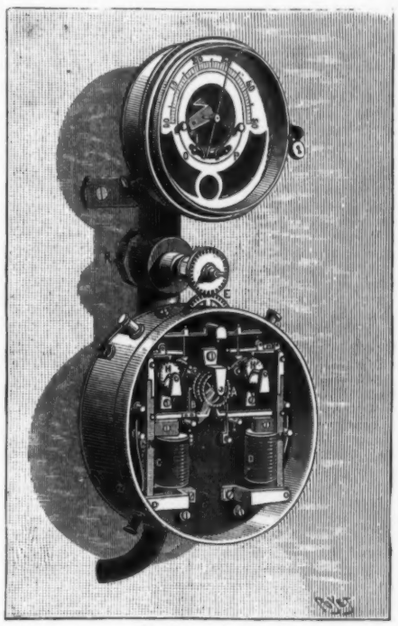
A manometer whose dial is represented at the upper part of the engraving is connected with the service pipe whose discharge is to be regulated. The dial is provided with a peculiar arrangement which permits of causing, at the moment the hand reaches a certain degree of the graduation, an electric contact that is utilized in the manner described further along. The pipe is controlled by a cock, R, and it is by the automatic varying of the opening of this that the inventor succeeds in obtaining a perfect regulation, despite the variation of pressure of the gas works. This cock is connected by a series of gearings (a part of which may be seen at E) with two small electric motors that are capable of acting in opposite directions. One of these motors opens the cock in the direction of the widest aperture and the other in the direction of the smallest. The principal parts of these motors are visible in the engraving. Let us examine one of the two—the one to the left, for example.

The electro-magnet, C, has for an armature a piece, N, parallel with its core and pivoting at the bottom. Toward the center, it is provided with a piece, B, at right angles, which acts under the toothed wheel, A, and, at the top, with a small ratchet that acts upon the wheel, H. As soon as the current passes into the electro, C, the armature, N, is attracted and the ratchet, B, revolves the wheel, A, one notch; but the current is immediately broken in consequence of the movement of the armature. The latter, under the influence of a spring, then returns to its starting point, and, at the same time, the ratchet at its upper part carries along the wheel, H, the object of which is to establish a new and much preciser contact than that adopted for electric bells. When the current again passes into the electro, things begin again as before, and so on.

The wheel, A, is moved always in the same direction by a series of quick strokes of the piece, B, and is mounted upon an axis which, through a series of gearings, acts upon E, and consequently upon the cock, R.

The operation of the apparatus will now be easily understood. It will be seen that the dial of the manometer is provided with two contacts, O and P, mounted upon a marble disk concentric with the dial. It is consequently possible to bring these contacts to the point corresponding to the determined position of the hand. The latter is connected with one of the poles of the battery, while the contacts, O and P, are insulated and correspond, one of them, to the electro, C, and the other to the electro, D. The circuit will consequently be closed upon one or the other of these two electros, according as the hand rises or descends with the variations of pressure. Let us suppose that it tends to rise; then its lower part immediately touches the contact, O, and sends the current into the electro, C, which, acting upon A, opens the cock in the direction of the narrowest aperture. The pressure at once diminishes, the hand of the manometer leaves the contact, O, and everything stops. If the pressure diminishes too much, the hand, in continuing to move, produces a contact at P. The current is then sent into the electro, D, which acts upon a toothed wheel like A, and seen behind it in the figure. This wheel actuates, in a direction contrary to the first, the gearings, E, and the cock then opens in the direction of the widest aperture, and an equilibrium is re-established.

We observed this apparatus in operation at the universal exposition, in the gas pavilion and various other places, and found that it acted with great rapidity and precision. It will certainly prove very useful in workshops, colleges, and all buildings in which a large quantity of gas is consumed, and especially in those in which the consumption varies from one moment to another according to the requirements of either light-



ELECTRO-MAGNETIC GAS REGULATOR.

ing or heating, for the device can be applied to a thermometer as well as to a manometer. In conclusion, we may remark that it might be easily utilized for automatically interposing resistances in a circuit of electric distribution.—*La Nature.*

PROTECTIVE RULES RELATING TO ELECTRIC LIGHTING.

A SPECIAL circular of the Boston Manufacturers' Mutual Fire Insurance Co. is as follows:

Electric lighting was first introduced in a very few risks insured by this company before the year 1881; in that year, and in the first six months of 1882, it was adopted in a very considerable measure. In this period of its early introduction, prior to the first of April, 1882, we received notice of twenty-three fires which had been set by the electric current in only sixty-one mills which had then been equipped. No claim for loss was made on any of these fires, but they disclosed conditions which were very alarming to us. An immediate investigation was made, under the direction of Mr. C. J. H. Woodbury, and certain rules were adopted for putting up the apparatus, insulating the wires, and guarding against the dangers disclosed in these twenty-three fires. These rules were immediately submitted to all the electric light companies or manufacturers of electric lighting apparatus who had any standing in the community, and were at once adopted by them, as well as by all insurance companies. They have not been changed since that date, except so far as new inventions have called for modifications.

Since April 1, 1882, a period of nearly eight years, we have received no notice of any fire which could be attributed to electricity in any risk insured by this company, and, of course, no claim has been made upon us for a loss which could be attributed to this cause. Our experience, therefore, justifies the conclusion to which we came after the first two years of electric lighting, that under proper safeguards it is the safest method of lighting that can be introduced. Electricity has also

been applied in some of the works insured by us as a motive power, and electricity is now applied to lighting or motive power in over six hundred risks which are insured by the factory mutual companies.

Attention, however, has lately been called to the danger of wild currents of electricity generated on the wires which may be in use for lighting, for power, and for the railway service in many cities. There appears to be very little doubt that the recent destructive fire in Boston originated in the diversion of a high tension current of electricity from its own wire to an electric clock wire, on which it was carried to the building in which the fire originated. There appears to be little doubt that this conflagration may be attributed to the lack of precaution in guarding against an outside current of electricity. Such currents may be carried from their proper wires to other points in all cities or towns in which electric light or power is widely distributed on the public streets or over private buildings.

In order to guard against this hazard, the owners and managers of mills and works insured are advised to establish the following rules for the protection of their premises. These rules, after having been drawn by us, have been submitted to experts in various branches of electric science who are of the highest authority. The forms have been modified by them, again considered on our own part, and are believed to be suitable for what may be called an emergency.

RULES FOR GUARDING INSURED PROPERTY AGAINST THE HAZARD OF STRAY CURRENTS OF ELECTRICITY GENERATED OUTSIDE OF MILL YARDS.

1st. No foreign wires of any kind shall be attached to buildings insured by this company, for the purpose of carrying electric currents across the yard to any point.

2d. All electric wires which may be required by the insured shall enter the premises at one point near the headquarters of the night watchman, where they can be kept under supervision; each of said wires shall be guarded by a protector against strong currents, operating by opening the circuit, and by a lightning arrester.

3d. Such protectors against strong currents shall be located in a dry, accessible place inside the building, and as near the point of entrance of wires as possible, and shall be without ground connection; such protectors shall be mounted on non-combustible and insulated supports, which shall be provided with a receptacle for the burning or melted parts of such apparatus.

4th. The lightning arresters on all wires must be placed between the protector against strong currents and the electrical portion of the apparatus within the building to which such wires are connected. No ground wires for such lightning arrester shall be attached to gas pipes within the premises of the insured.

5th. All electric wires which may enter the premises of the insured must be insulated between the line wire on the insulator attached to the buildings outside and the protecting device within, with the best quality of waterproof insulation. Moreover, such wires must enter at a distance of not less than three (3) inches from any other wire or any conducting material.

6th. If any wires carrying high tension or strong currents are to be carried over or under other wires on the property of the insured, they shall be attached to poles so near to each other, with one wire so far above the other, that if a break should occur, the pendent wire between these poles may not be long enough to come in contact with the wire below, or, if not carried on poles, these wires shall be so placed or protected with guard wires as to render a contact between different wires impossible.

7th. If the high and low tension systems are in use in the same yard, even when developed within the works, the wires must be kept separate, and so wide apart that no contact or cross arc can be made.

SIBLEY COLLEGE LECTURES.—1889-90.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

II.—THE HISTORY OF AERONAUTICS.

By Prof. W. LE CONTE STEVENS, of Brooklyn, N. Y.

IN the history of any art that is a century old there is always much that, as busy men, we can afford to forget. The art of aeronautics presents no exception to this rule, but it contains too much of real value to encompass in a single lecture. It will be possible only to select a few representative chapters in this history and show, if possible, their bearing on the present condition of aerial navigation.

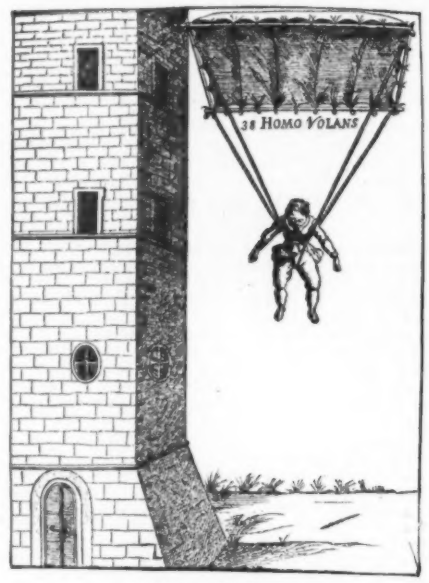
Ballooning has been largely a French art; introduced by a Frenchman, Montgolfier; rapidly developed by another Frenchman, Charles; more practiced in France than anywhere else; and recently improved by Frenchmen to such an extent that it is now quite possible on any fair day to take an afternoon excursion through the air and return with precision to the exact point of departure.

Among the ancients flight was considered the special prerogative of but two classes of beings, birds and gods. For men to attempt it was hazardous, if not impious. A few favored individuals, like Perseus, are mentioned in fable as gifted with the power of aerial locomotion by the aid of winged horses or otherwise; but this was always due to the aid of some divinity. Icarus, the too self-reliant son of a cautious father, is represented to have lost his life by ambitiously trying to fly at too great a height, using wings that had been cemented to his shoulders with wax, and thus incurring the wrath of the god of day, who melted the wax with his ardent rays and precipitated the offender into the Icarian sea.

No credit is to be attached to any of the speculations, or alleged experiments in flight, that are handed down from the middle ages. Roger Bacon claimed the power of flight, but failed to substantiate his claim by the record of any experiment. Between 1657 and 1659 the inventive powers of Robert Hooke were exercised in devising as many as thirty methods of flying; but with characteristic impatience he developed none of them so far as the experimental stage. The world will probably always present its annual crop of visionaries who are ready to expend time and labor on flying machines, heedless or ignorant of what has been already tried in vain, and devoid of any conception as to the necessary relation between the power to be applied and the work it must accomplish.

Even prior to 1680 it was demonstrated by Borelli, in a posthumous work published at Rome and entitled "De Motu Animalium," that human beings could never rationally hope to rise into the air by muscular power so long as the human frame remains what it now is On mechanical principles he showed that the necessary power would be possible only on the assumption that the human breastbone shall present several times as much surface as it now has for the attachment of muscles, and that these shall have many times the power exhibited by the best of athletes.

But, despite Borelli's demonstration, sundry attempts were made to sail through the air by leaping from lofty places and employing some device for utilizing the resistance of the air and diminishing thus the speed of descent, while the horizontal impulse is but little checked. The flying squirrel presents an example of success in this method of partial flight.



HOMO VOLANS.

In a manuscript volume entitled "Novæ Machinæ," and published in 1695, is found the accompanying representation of a *homo volans*, where comfort seems to be somewhat sacrificed in the pursuit of science under difficulties. It is remarkable chiefly as the first embodiment of the idea of the parachute, an adjunct to the balloon that was for awhile deemed of importance, but which has now ceased to be used for any other purpose than that of sensational display.

Even if the power of flight, or of sailing through the air, be denied human beings, there still remained another resource, vaguely foreshadowed by Roger Bacon during the thirteenth century, and elaborated in theory about 1670 by Father Lana, a Jesuit priest. It was that of rising into the air by the aid of some body whose weight was so small in proportion to its volume as to be more than counterbalanced by the buoyancy of the air. Bacon had suggested the use of "ethereal air or liquid fire" to be put into a thin hollow globe of copper; but he gave no recipe for its manufacture.

His speculation was as worthless as the rest of the science of his time. Lana differed from his predecessor in one important respect, that his plan involved the application of correct physical principles, though he failed to take into account certain other elements that in practice cannot be disregarded. He knew nothing about the specific gravity of gases, but had clear conceptions about atmospheric pressure. His plan was to exhaust four hollow globes of copper, each 25 feet in diameter and $\frac{1}{12}$ inch in thickness, and attach to them a basket or car for passengers. A mast and sail were provided in the hope of partially controlling the motion of his machine. Torricelli had in 1643 demonstrated the pressure of the atmosphere; and the method proposed by Lana for exhausting his globes was to fill each with water and lift it to a height of 36 feet. Beneath it should be fitted a tube with air-tight connections which was to dip into water. On opening this tube the contents of the globe would be emptied into the vessel below, leaving a Torricellian vacuum above, while the tube would become a water barometer, and might be then closed at its upper end. The upward pressure of the air at sea level against such a globe would be about 659 pounds. The weight of the copper would be not quite 400 pounds The effective ascensional force would, therefore, for the four globes, be rather more than 1,000 pounds, which would be amply enough to sustain the weight of the connecting tubes, car, and aeronaut, and to leave a good margin for such food and other freight as he might carry. It is scarcely necessary to say that this plan was never reduced to practice, since Lana had made no allowance for the crushing weight of the water with which his globes were to be filled before exhaustion. Sheet copper $\frac{1}{12}$ inch in thickness would have been wanting in the rigidity required to sustain such a burden. Even if the vacuum had been attained, the globes would then have been crushed by the surrounding atmosphere. Lana foresaw this last difficulty, but supposed that, since at any point the air pressure is equal in all directions, his spherical shell of copper would be uniformly compressed and actually strengthened by the force applied from outside. To his theological mind the only serious objection to the scheme was that "the Almighty would never allow an invention to succeed by which civil government could be so easily disturbed." This may have been a happy afterthought suggested by the difficulties of construction.

A century now elapsed without the accomplishment of any new plans for aerial locomotion. Soon after the discovery of hydrogen gas by Cavendish and Watt in 1766, experiments were made with a view to utilizing it for the purpose of lifting bodies into the air. But until 1782 nothing more substantial than a soap bubble could be made thus to ascend.

In the autumn of that year, Stephen Montgolfier, a successful manufacturer of paper at Annonay, in the southeastern part of France, tried bags of this material filled with hydrogen; but the gas diffused so rapidly through paper that the experiment was abandoned. Without being a physicist, Montgolfier was thoughtful and fond of experiment.

While visiting shortly afterward at Avignon, observing that clouds of vapor and smoke remained floating at various heights, he conceived the idea that if they could be confined in bags of paper, these might be made to float in like manner.

Since the experiments of Franklin in 1752 had proved the existence of atmospheric electricity, the idea gained currency that the lightness of clouds and smoke was in some way due to electric charge. The problem then was to produce a cloud artificially, electrify it, and confine it in paper. Chemistry was not yet a quantitative science.

There was a charm in the idea that electricity was one of the products of all chemical action, and especially when acids and alkalies were brought together. By burning straw a cloud of smoke was evolved, with an abundance of carbonic acid. By burning wool one of the products was an alkaline gas. By burning straw and wool together the hopeful conditions seemed to be attained.

A paper bag was made, with a capacity of 30 or 40 cubic feet, and with its opening downward it was held over a fire of chopped straw and wool, "as well to increase the layer of electric fluid upon the vapor in the vessel as to divide the vapors into smaller molecules and dilute the gas in which they are suspended." The bag was carried up to a considerable height. The experiment was soon repeated on a larger scale and with encouraging success.

Montgolfier then announced that he would give a public exhibition of his wonderful discovery at Annonay. He seems not to have attributed the ascension of his bags to the effect of heat in diminishing the specific gravity of the confined air, but thought he had discovered a new kind of gas whose peculiar properties caused their levitation. The first successful experiment in ballooning was thus based on a radical misconception.

The public exhibition was given at Annonay on the 5th of June, 1783. The bag was made of linen gores lined with paper and loosely buttoned together at their edges. It was nearly spherical in shape, with an opening at the bottom, to which was suspended a wire netting with about 10 pounds of the new and wonderful fuel. In round numbers its weight was 500 pounds, its diameter 35 feet, and its capacity 23,000 cubic feet.

Despite the waste of hot air due to the rough method of construction, the balloon was fully inflated in less than a quarter of an hour, rose to a height of 2,000 feet or more, was wafted more than a mile, and reached the ground after an aerial journey of fifteen or twenty minutes.

The news of this success quickly reached Paris, where a subscription of 10,000 francs was at once secured for the purpose of repeating the Annonay experiment.

The work of constructing a balloon was confided to the two brothers Robert, under the superintendence of M. Charles, a young physicist who had already achieved distinction by his investigations regarding the atmosphere and the effect of heat on gases.

Charles at once discerned the true cause of Montgolfier's success, and independently thought out a better way of attaining the same result by employing hydrogen instead of hot air, and confining it in a bag much tighter than one of gores buttoned together. For his material he employed thin silk, which he covered with a resinous varnish, so as to make it effectually gas tight. Its diameter was only 12 feet, and its capacity about 900 cubic feet. Before the fourth week in August it was ready for inflation, and the work of filling was begun in the open space of the Place des Victoires. Unforeseen and serious difficulties were encountered in the preparation of the hydrogen. This was the first attempt to procure this gas on a large scale. Into a barrel partially filled with iron filings two lead tubes were inserted through the top, one for the introduction of dilute sulphuric acid, the other for the delivery of the resulting impure hydrogen. This was conveyed directly through the neck of the balloon, without the intervention of any wash bottle. Much heat was produced by the chemical action, and the result was that a quantity of steam was sent out along with the hydrogen and condensed on the walls of the silken bag, heating this so as to melt the varnish and injuring the silk with the acid vapors. It was necessary to throw streams of cold water on the outside of the balloon to counteract these annoying effects, and through injuries to its texture nearly nine-tenths of the gas actually made was wasted. It took four days to inflate the balloon with 700 cubic feet of gas, which was only about three-fourths of its capacity. Meanwhile the populace had become so impatient that it was deemed unsafe to remain another day exposed to the danger of interference from an indignant crowd. During the night the balloon was conveyed, under military protection, to the Champ de Mars, about two miles away, the site of the recent Paris exposition. Here the inflation was completed, and at five o'clock in the afternoon of the 27th of August a cannon shot announced to the city that the balloon was released. In two minutes it rose 3,000 feet and was lost to sight in a cloud. A storm had been gathering, and the rain began to fall. The balloon reappeared, and a second cannon shot was fired. Thousands of men, women, and children were drenched in the rain before the balloon was again lost to view. In three-quarters of an hour it was carried fifteen miles to the northeast, and fell near the village of Gonesse, to the great consternation of the peasants, who were unprepared for such an apparition, and attacked it as a creature of infernal origin. As they mangled it the sulphurous odor of impure hydrogen was enough to confirm their preliminary suspicions of its diabolic character.

On learning the fate of his balloon, Charles perceived that he had carried the inflation too far. Since the external pressure diminishes with increasing height, there was corresponding increase in the effective expansive force of the gas in the balloon. A rent was

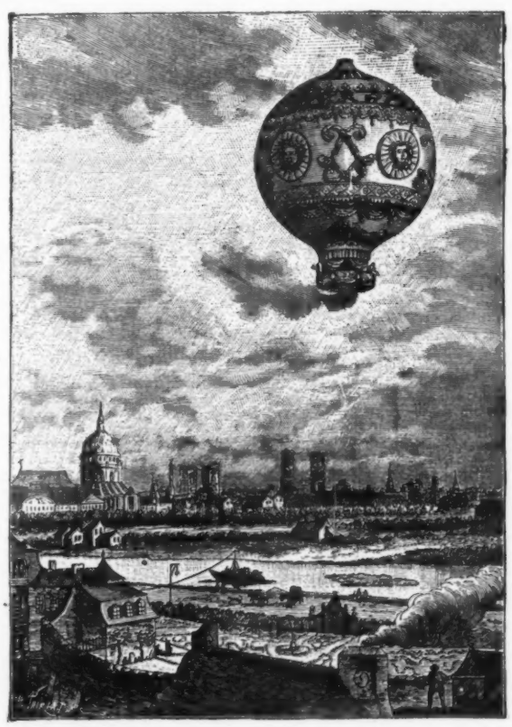
made in the silk, and with increasing leakage the balloon gradually descended. Charles at once decided to make another trial; and his recent annoying experiences suggested to his fertile mind decided improvements in both the construction and the inflation of his next balloon.

Immediately after the experiment at Annonay, Montgolfier was invited to Paris, where he was received with distinguished honor by the king and court. He constructed a large and magnificent balloon, which was ornamented in the most elaborate style, and he was invited to make it ascend at Versailles in the presence of royalty and the aristocracy of France. By means of his chopped straw and wool the inflation was accomplished in eleven minutes in the afternoon of September 19. Before releasing the balloon a basket was attached, in which had been placed a sheep, a cock, and a duck. These pioneer aeronauts were gently carried to a height of 1,500 feet, remained in the air eight minutes, and descended, reaching the ground in perfect safety at a distance of two miles from the point of departure.

The people were now wild in their enthusiasm about the new art, and Montgolfier was the hero of the hour. A distinction was made between the two kinds of balloon that had been recently exhibited, the Charlière and the Montgolfière. From a scientific standpoint the former was much the superior of the two. For the purposes of popular sensation the latter was decidedly better thus far, because the time required for inflation was so brief, and the trouble and expense involved in this operation were so small. The supposed discoverer of a new kind of gas was therefore triumphant, and the more accurate and well informed man of science was for a time deprived of the credit which was justly due him. This case, however, is not singular in the history of invention.

Charles announced his intention of ascending in a new balloon which he had begun to construct. The popular party at once undertook to anticipate him, and application was made to the king for permission to send up two condemned criminals by way of experiment. If they should be killed, this new mode of accidental execution had at least the merit of novelty. A young naturalist, Pilatre de Rozier, protested against granting to a criminal the honor of making the first journey through the air, and offered himself to run the great risk involved in the use of fire to lift him to a height at which an accident could scarcely be anything else than fatal. He first ascended about 70 feet in a captive Montgolfière, and was pulled down in safety. Two more experiments of the same kind were then made, in which heights of 200 and 300 feet were attained. He then induced his friend, the Count d'Arlandes, to make a public ascension in company with him. A large crowd gathered in the Bois de Boulogne, on the 21st of November, to witness this new and thrilling spectacle.

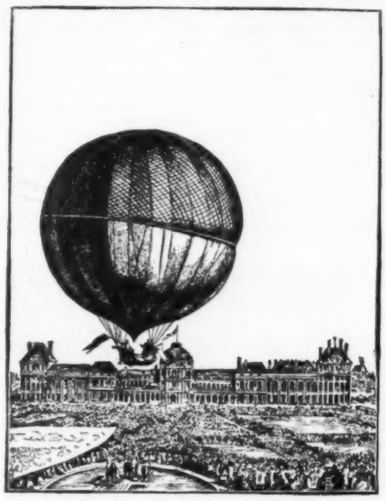
The balloon was provided with a balcony around the opening at the bottom. In this the two aeronauts placed themselves with a generous supply of straw, wool, and water, so as to feed or partially extinguish the fire which was made on a brazier immediately below the opening. The capacity of the balloon was about 100,000 cubic feet, and its diameter nearly 60 feet. It rose majestically to a height of 500 feet and was carried by the afternoon breeze about five miles in a direction slightly south of east, crossing the Seine and floating over the southern part of Paris. Its elevation was sustained by adding fuel, and water was used to extinguish the fire prior to a safe descent a half hour after the start. This success decided Rozier to devote himself to ballooning. Two years later he paid the penalty of his life for trusting himself to a fire balloon to which a Charlière was attached.



FIRST ASCENSION IN A FIRE BALLOON.

The first human aeronaut was the first victim of the new art, so fascinating in its novelty, so dangerous in its application, at least where Montgolfier's method was employed. During the last century many thousands of air voyages have been made, with the loss of not over fifty lives. Of these casualties the majority have been due to the use of the fire balloon, though the number of ascents made with the balloon filled with hydrogen or coal gas has been probably twenty times as great.

The first ascent in a hydrogen balloon was made by Charles and Robert on the 1st of December, 1783, ten days after the journey of Rozier and Arlandes. The cubic capacity of Charles' new balloon was only one-tenth of that of Rozier's. It was provided with a safety valve at the top, which could be controlled by the aeronaut below through the medium of a cord. It was surmounted with a netting of silk, which was fastened to a ring that girded the balloon. From this was suspended a car or basket, with seats for two persons, whose weight was thus distributed over the whole upper surface of the supporting sphere. Indeed, in all important particulars this balloon, as designed by Charles, was the same as that almost universally employed since his day. The ascension was made from the garden of the Tuileries in the presence of a vast concourse of people, among whom was the American minister, Benjamin Franklin. Charles took with him a barometer and thermometer for noting the changes of atmospheric pressure and temperature produced by change of elevation. At a little before two o'clock in the afternoon the balloon rose with its pair of voyagers to the height of 2,000 feet, and was carried twenty-seven miles northwest to the town of Nesles, where a safe descent was made. Here Robert got out, and, as there was no ballast at hand to replace his weight, on releasing the balloon Charles was rapidly carried to a height of nearly two miles, as shown by the fall of the barometer from thirty to twenty inches. The thermometer at the same time fell from 41° to 21° F. The sun had just set, but on rising to such a great height Charles enjoyed the rare opportunity of witnessing two sunsets on the same day by the widening of his horizon as the balloon ascended. He remained a half hour in this second sunshine, and beheld his second sunset as he descended about three miles from Nesles. The only inconvenience felt in consequence of his rapid change of elevation was that of violent but temporary pain in his right ear and jaw. This voyage, in comparison with the previous one of Rozier, was remarkable for the great height attained—twenty times that of Rozier—for its demonstration that the aeronaut's flight could be prolonged many hours with no labor on his part in controlling the changes of elevation, and that it afforded a valuable means of investigation in the study of the atmosphere. Despite his encouraging success, there is no record that Charles attempted any subsequent aerial voyages.



CHARLES' BALLOON.

Six weeks after this ascension by Charles and Robert, the largest balloon on record was made and sent up from Lyons. Its capacity was half a million cubic feet, if contemporary accounts are fully worthy of credit. It was inflated over a straw fire in seventeen minutes, and rose to a height of half a mile, the fire being kept up with fresh supplies of straw. It remained in the air only a quarter of an hour. One of the seven persons who ascended with it was Joseph Montgolfier, the brother of the rival of Charles. Stephen Montgolfier made no ascent himself.

It is singular that after these initial successes in France the first ascent attempted elsewhere should be in America, a country not only separated by a broad ocean from France but at that time young in resources and scarcely beginning to recover from the effects of an exhausting struggle for independence. It is true that in November, 1783, a small hydrogen balloon was sent up from London without any living freight. The English seemed to feel no disposition to follow up the invention of their French enemies, and it was an Italian, Count Zambeccari, who in London imitated the experiment made by Charles at the Champ de Mars. No one rose from English ground in a balloon until a year after the first success of Charles in Paris.

The news of Montgolfier's experiment of the 5th of June reached Philadelphia about the last of November, and the local papers of December 24th contained the accounts just received of Charles' experiment of the 27th of August. David Rittenhouse, the friend of Franklin, and the most distinguished American astronomer of his time, was practicing his profession as a maker of clocks and philosophical instruments. One of his most intimate associates was Francis Hopkinson, an eminent jurist, whose interest in science was as great as his proficiency in law. Both of these men were members of the American Philosophical Society, which had been organized by Franklin.

On the 28th of December they made an experiment, the account of which is perhaps best given in the language of a French eyewitness, Francois Simonin, whose letter to the *Journal de Paris* was published May 13, 1784. In the *Gentleman's Magazine* of the following month a translation of it appeared, from which the following is an extract:

"Messieurs Ritnose [Rittenhouse] and Opquisne [Hopkinson] began their experiments with bladders, and then with larger machines. They joined several together and fastened them round a cage, into which they put animals. The whole ascended, and was drawn down again by a rope. The next day, which was yesterday, a man offered to get into the cage, provided the rope was not let go. He rose about fifteen feet, and would not suffer them to let him go higher. James Wilcox, a carpenter, engaged to go in it for a little money. He rose twenty feet or upward before he made a signal to be drawn down. He then took instructions from Messieurs Ritnose and Opquisne, and after several repetitions on the ground consented to have the rope cut for fifty dollars. Dr. Jaune [Jones], the principal medical person in the city, attended in case of accident. The crowd was incredible, who shouted after the English fashion when they saw Wilcox rise crowded in the cage, surrounded by forty-seven balloons fastened to it, with astonishing coolness, nodding his head to express his satisfaction and composure. After all, he could not rise above ninety-seven feet, according to the measures taken by two other gentlemen of the Philosophical Academy. He was at least five minutes in the air, but, perceiving the wind to blow from the east and drive him toward the Scoulquille [Schuylkill], he was frightened, and, agreeably to his instructions, made several incisions with a knife in three of the balloons. This was not sufficient, though we saw him descend a little. He pierced three more, and, seeing the machine did not come, his fear increased. He cut five more in the greatest haste, and, unfortunately, all on the same side. He was then seen to tack about, and, as if he had slid down, he fell on the edge of a ditch and a finse [fence], as they call the inclosures. Dr. Jaune ran up; the poor man had sprained his wrist, but received no other accident."

This circumstantial account leaves no reason to doubt its substantial truth; but the experiment was not followed up, and Rittenhouse seems not to have regarded it as important. It is not even mentioned by his biographer, Barton. That Hopkinson was interested in balloons was indicated by some of his correspondence with Franklin.

Probably the most ambitious voyage made in the early days of ballooning, and one of the most perilous, was the crossing of the English Channel in the afternoon of January 7, 1785. During the previous year M. Robert, the colleague of Charles, attempted the propulsion of a balloon by means of oars, but in vain. He subsequently tried artificial wings, but with no better success. M. Blanchard began his long career as a professional aeronaut about the same time, and tried a variety of similar devices without success.

Dr. Jeffries, an American physician, who had removed his residence to London during the war of the revolution, became interested in aeronautics, and employed the services of Blanchard, with whom he wished to test the use of wings and oars for the direction of the balloon and for controlling its ascent and descent. The balloon was inflated on Dover Cliffs, the day being clear and cold, with a fresh breeze blowing from the northwest. Several sand bags were taken to use as ballast, and also a barometer, thermometer, oars, wings, and heavy clothing. Scarcely had the balloon been released from its moorings when it was discovered that the inflation was insufficient, and most of the ballast was thrown out at once. The wind carried the aeronauts gently toward Calais, but when they were scarcely a third of the way across, the balloon was found to be descending, and the rest of the sand was thrown out. Ere long they were descending again; some tools, an anchor, rudder, oars, wings, heavy clothing, and food were committed in succession to the waves. Despite all, the balloon slowly approached

the water, no land being visible in any direction. The spray was splashing on them from below, and but one resource was left; to fasten themselves to the cordage of the balloon and cut the boat loose, in order to diminish the weight. They had already tied themselves to the netting, when a movement of ascension was felt. The balloon was lifted gradually, and Calais was seen in the horizon. It rose half a mile high, passed over the city, and a descent was made fifteen miles inland in the forest of Guines.

The explanation of the perils to which Jeffries and Blanchard were exposed is not hard to find. The buoyancy of the cold dry air from the English mainland was enough to keep the balloon floating at a safe height. But when this was first mixed and then exchanged for the warm, moist sea air of less density, the balloon naturally sank in it. On approaching the French coast, it entered another bed of denser air, which had been cooled and dried by the land. The balloon, therefore, rose, and to a greater height than at first, because so much ballast had been discarded.

Six months after this remarkable voyage, Pilatre de Rozier, emulating the example that had been thus set, lost his life in the attempt to cross from France to England. Ballooning had become popular everywhere. Balloon almanacs and balloon poetry were among the evidences of the widespread mania; and from that day to the present the balloon has been devoted chiefly to the purposes of sensational display. Among the famous professional aeronauts may be mentioned the names of Zambeccari, Lunardi, Blanchard, Garnerin, the Sadlers, Green, Coxwell, and the brothers Godard. Among feminine aeronauts the wife of Blanchard became famous. She was killed in 1819, while making a display of fireworks at night in a balloon over Paris. To Mr. Charles Green is due the credit of first substituting coal gas for hydrogen, thus rendering the inflation of the balloon much cheaper and easier, though the balloon thus filled needs to be larger. Mr. Green made more than 500 ascents, and fell twice into the North Sea. In 1828 he made the first ascent on horseback.

In America John Wise was probably the most famous aeronaut, a man of fine natural ability and of much greater scientific attainments than is usual among men of this business. In 1859 he made a balloon journey with three companions from St Louis to Jefferson County, N. Y., a distance of 1,150 miles, in a little less than 20 hours, at a mean rate of nearly a mile per minute. He believed in the existence of a constant upper current from the southwest in the region of anti-trade winds, and hoped by this means to cross the Atlantic in a balloon. Such a voyage was projected in 1873, but never realized.

The balloon has at various times been used for military purposes, as a means of spying out the movements of a distant enemy. During the American civil war a balloon corps rendered efficient service under Mr. Lowe. A telegraph operator in the car of a captive balloon has often thus given information that could be available in no other way. During the siege of Paris in 1870 and 1871, as many as 64 balloons were sent up from the beleaguered city, making the ascent at night. Five of these fell into the hands of the Germans; one was carried off and lost in the Atlantic; one, after traversing the North Sea, was landed in Norway fifteen hours after the start; and the remaining 57 descended safely in France. Gambetta escaped from Paris in one of these. Not one of them succeeded in re-entering Paris. Nevertheless it is for military purposes that the balloon has probably its best field in the future.

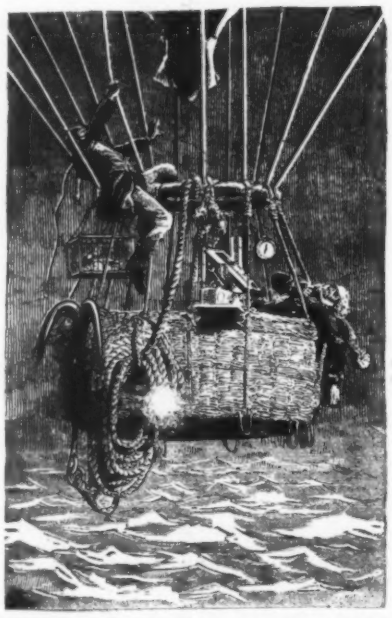
The application of the balloon to scientific purposes was first made by Charles, as already indicated, but only in a single voyage. It was not until 1804 that ascents were again undertaken for the study of the atmosphere. The first was by M. Sacharoff, at St. Petersburg, who attained a height not exceeding 8,000 feet and discovered nothing of importance. Echoes from the earth were very distinct, even when the distance was such as to produce an interval of ten seconds.

In August, 1804, Gay Lussac and Biot ascended together from Paris to a height of 13,000 feet, their principal object being to ascertain whether there was any perceptible decrease in the earth's magnetic effect with increase of elevation. The result was negative. During the following month Gay Lussac ascended alone to a height of 23,000 feet. His observations on terrestrial magnetism confirmed those taken during the previous voyage. Air brought down from this lofty height was found to have the same composition as that at the earth's surface. The temperature fell from 82° to 15° F. as he rose, and at the highest point clouds were visible far beyond against the deep blue sky.

In July, 1850, Bixio and Barral ascended from the Paris Observatory. While in a cloud, at an elevation of 20,000 feet, the temperature was 15° F. On emerging from it, at 23,000 feet, the thermometer fell to —38° F., or 53° F. lower than the record made by Gay Lussac at the same level. This arctic temperature is probably the lowest ever recorded in a balloon voyage. It shows that no formula for decrease of temperature with increase of height can be accepted without many grains of allowance.

In the summer of 1852 several ascents were made by Mr. Welsh, of the Kew Observatory, near London. In these the decline of temperature was found to be quite regular.

At the Aberdeen meeting of the British Association in 1859, a committee was appointed to make observations in the upper atmosphere by means of the balloon. Nothing was accomplished until 1862, when in July Mr. James Glaisher began a series of twenty-eight ascents, the last of which was made in May, 1866. The primary object was to determine the temperature and moisture of the air at different elevations to the greatest height attainable, though many secondary objects were additionally kept in view. Mr Glaisher carried each time an abundant supply of well-arranged instruments, and his experience and skill as an observer made his work the most important ever accomplished in this special domain. The most remarkable of his ascents was that undertaken on the 5th of September, 1862, from Wolverhampton, a town near the center of England. The intention was to reach the greatest height possible. The balloon left the ground at a few minutes past one o'clock, and at the end of 45 minutes a height of five miles was reached. Mr. Glaisher began to grow faint on account of the rarefaction of the air. When half a mile more had been mounted, Mr. Glaisher lost the use of his hands and limbs, the temperature being 5° F., and the height of the barometer only 9¾ inches. A few moments afterward he fell back insensible in the car. His companion, Mr. Coxwell, who had been employed as aeronaut, here attempted to stop the ascent by pulling the valve rope; but this had become twisted on account of the rotary motion of the balloon. It was necessary to climb up into the rigging to disentangle it. On attempting to come down he found his hands frozen and insensibility beginning to creep over him. Placing his arms on the ring, he dropped down into the car. After several ineffectual efforts he succeeded in catching the valve rope with his teeth, and by dipping the head a few times he caused the escape of enough gas to make the balloon take a decided turn downward. Glaisher soon recovered and resumed his observations upon the instruments. During the few moments before he became insensible, the balloon had been rising at the rate of 1,000 feet per minute. Thirteen minutes of insensibility followed, and the rate of descent was found to be 2,000 feet per minute. A minimum thermometer indicated that the lowest temperature attained was —11·9° F., and Coxwell observed the lowest barometer to be 7 inches. These data warranted the conclusion that the maximum elevation had been 37,000 feet, or 7 miles. The first 3 miles of descent were accomplished in 9 minutes. The balloon was then checked by throwing out ballast, and the ground was reached in safety, about 100 minutes after the departure from Wolverhampton.



GLAISHER INSENSIBLE AT THE HEIGHT OF SEVEN MILES.

The detailed observations made by Mr. Glaisher during his long series of aerial voyages were duly published in the reports of the British Association. He established the existence of a warm aerial current sweeping over England, as the Gulf Stream sweeps through the Atlantic Ocean. At any given spot, however, this current is subject to fluctuations. He found that the velocity of the wind was much greater at lofty heights than near the ground, and noted the intensely deep blue color of the sky at such elevations. The explanation of this fact has since been worked out by Tyndall, and still more thoroughly by Langley, being found in the atmosphere's power of selective absorption. Sounds from the earth were found by Mr. Glaisher to be more or less audible, according to the degree of moisture in the air. When in a cloud at the height of four miles, he heard distinctly the rumbling of a railway train; but when in clear air, with the cloud between him and the earth, the sound was inaudible, even though his elevation remained unchanged. At a height of two miles the barking of a dog was heard when the atmosphere was clear and dry; but the shouts of a multitude of people were unheard when the intermediate air was moist, at a distance of three-fourths of a mile. This confirmed Tyndall's experiments, subsequently made, on the acoustic opacity of bodies of air that may be optically transparent. These are but a few of the many valuable observations made by Mr. Glaisher.

(To be continued.)

[Continued from SUPPLEMENT, No. 737, p. 11777.]

THE CHEMISTRY OF GLASS.

By Prof. GUSTAV GEHRING.

ALL objects of glass, after they have been formed, should be cooled very slowly. If a mass of molten glass be suddenly dropped into cold water, its molecular constitution is changed, it becomes less dense, and the fragments, to which it may be reduced, present no longer sharp edges.

A Prince Rupert's drop is but an extreme case of unannealed glass. Its manner of rupture is quite characteristic. When embedded in plaster of Paris it disintegrates in little scales, which all point in the same direction.

De Luynes thinks it is formed by the superposition of unequally tempered layers of glass, and consequently unequally dilated. He compares such a drop to a series of superposed caoutchouc pears, blown up under pressure and sealed, all uniting by their necks, which are subjected to a single ligature. It is evident that in destroying the part common to all the necks, the equilibrium of the system will also be destroyed. This is shown by the fact that the stem can be eaten off by hydrofluoric acid, up to a certain point, without causing the drop to burst. Also, at the broad end, each layer can be successively cut or removed without destroying the whole; the interior layers maintain the equilibrium of the system.

A Rupert's drop, about five millimeters in diameter, when observed in phenic acid, shows five or six colored fringes of great brilliancy. Its molecular condition is analogous to that which would be produced in a plate of glass subjected to a pressure of 1,600 atmospheres. Only the exterior part of a drop produces the phenomenon of colored rings under the polariscope. Ordinary glass is not endowed with the power of double refraction. It acquires this property, however, if by any cause its elasticity becomes more modified in one direction than in another.

In order to effect this, it may be strongly compressed in a given direction, or it may be curved or tempered. If the glass is then traversed by a beam of polarized light, effects of color are obtained which are entirely analogous to those described in the case of double refracting crystals. This test is very sensitive. Ordinary glass is always a little tempered. If not, it permits light to pass unobstructed, but when the glass is compressed there will be a black spot in the middle. In pressing still more, colored rings appear. But it is obvious that an enormous pressure is necessary in order to produce the rings of tempered glass.

A square glass plate, regularly tempered, shows under the polariscope a cross by allowing the light to pass in two lines which intersect, so as to virtually separate the plate into four equal squares.

Glass plates of that kind have been perforated by bullets in the center, or point of equilibrium, without being broken. They can also be cut into four pieces through the lines of equilibrium, but if cut anywhere else, they burst into a thousand fragments. On account of the explosive violence with which such objects burst, they are dangerous.

Attempts have been made to temper glass so as to obviate danger. This constitutes what is called toughened or hardened glass. It is formed by plunging the object red hot immediately into oil.

De la Bastie, the inventor of the process, has determined for many liquids the coefficient of solidity which they give to glass. In water it breaks almost every time, but pure grease and unrefined oils give excellent results.

I have seen a thin plate of toughened window glass resist a fall of 100 gramme weight through the distance of ten feet, and another plate, three-quarters of an inch thick, did not break under a weight of 500 grammes from a height of eighty feet. The resistance of toughened glass is at least tenfold.

For coarse objects, its price is not higher than that of cast iron, and its density is only about one-third as great. The tramways of the North Metropolitan, in London, use it for rails.

During the last exhibition in Paris, De la Bastie showed soup plates of toughened glass, imitating porcelain, which never chip when thrust against each other, and when thrown from a table resist at least eighty times out of a hundred.

Dry air or oxygen, at the ordinary temperature, are without influence on glass. Hot air turns flint glass black. Boiling water dissolves it readily, as was first observed by Bernard Palissy. Lavoisier, in 1770, when the science of chemistry was yet in its infancy, showed in a memorable experiment that water heated for 101 days is not converted into earth, as was then believed by some.

To the contrary, he found that the vessel had been decomposed, the alkaline silicate of the glass dissolved in water, and the insoluble lime silicate formed a deposit.

Stas, before entering on the determination of atomic weights, made experiments in view of ascertaining the degree of solubility of different kinds of glass

Dilute acids, with the exception of sulphuric acid, are less deteriorating than water. Alkalies must be avoided. New glass vessels are attacked more easily than old ones. Natural surfaces are much more resisting than those polished. Emery-ground necks and stoppers of bottles are very much attacked by liquids, as every chemist knows. In fact, there are no means for closing a bottle hermetically for any length of time and against all ordinary changes of temperature. India rubber deteriorates by oxidation, and cork does not close by itself. Substances like sealing wax or paraffine, which are often put over the corks, soon crystallize and are altogether delusive.

Glass, finely divided, such as glass cotton, is easily dissolved by water, especially when hot; it loses from 10 to 34 per cent. of its weight. Any kind of glass, when reduced to powder, will give with cold water an alkaline reaction, but with boiling water almost instantly. If it be flint glass, there will be formed in the hot water with hydrogen sulphide a black precipitate of lead sulphide, and the same in cold water, with sodium sulphide. Even moist air is not without effect. Thus we often see the window panes in old houses dimmed with iridescent streaks. On heating such panes little scales come off, which are different in composition from the non-irisated glass. Through atmospheric influences the alkaline silicates on the surface of the glass were washed out, and the alkaline earth silicates remain in the form of scales and impart to it that play of iridescence. This phenomenon is always found in the glass of ancient tombs.

Messrs. Fremy and Clemandot have shown that this aspect of antique glass can be produced artificially by heating it under pressure in water containing about 15 per cent. of hydrochloric acid.

Irisations of a different kind, but no less beautiful, have been produced by Lobmayer, in Vienna, by submitting the objects in the annealing furnaces, at a dark red heat, to the action of vapors, such as subchloride of tin and the nitrates of barium and strontium.

Glass also changes under the influence of sunlight. Mr. Gaffield, of Boston, began in 1863 to expose more than a thousand different specimens of glass of all colors and widely different in composition, from one hour to thirteen years. He found that pure flint glass used for optical purposes is almost unalterable. White glass on exposure turns blue, but does not change wherever it is covered with red glass, unless it be removed.

A window pane, which was colored violet by an exposure to sunlight during twenty years, was still colorless where it had been protected by the frame. In many

cases the change of color is due to the reduction of manganese dioxide by the action of the sun. To evade coloration, Gaffield's experiments are of value, for they indicate where it is necessary to modify the composition of vitrifiable substances. Hence, metallic oxides, which do not impart color, such as the oxide of zinc, are preferable for the peroxidation of the salts of iron. Manganese dioxide in its function as glass maker's soap has been abandoned. Changes in color are often serious. It is well known that Bohemian glass turns slightly yellow by exposure to light. Merchants, therefore, keep such articles generally well enveloped, or preserve them in dark rooms.

Coloration in stained windows is common in Germany, and has been noticed even in the masterpieces of glass painting in Munich. For photographers it would be of great inconvenience. Plates having turned yellow, lose in large part their power of transmitting the chemical action of sunlight.

When molten glass is allowed to cool down very slowly, or when it is heated to softness for a long time, it loses its transparency and is converted into Reaumur's porcelain. This fact was observed by Reaumur in 1739. He heated a bottle, which was surrounded by a mixture of equal parts of sand and gypsum, very strongly for twenty-four hours and obtained a porcelain-like mass, which he called "porcelaine par devitrification."

Natural devitrification occurs frequently, especially in soda lime glass, or any other glass which contains an excess of silica or lime. It always begins at the surface, and in appearance may be plain, saccharoid, porcelain-like, granular, and even prismatic, like basaltic rock.

Devitrified blue glass has the beautiful aspect of marble. Pelouze, Benrath, and Stolba found that devitrified glass has the same composition as ordinary glass. Pelouze, therefore, thought that it was merely a molecular change, analogous to the transformation of amorphous arsenious acid into its crystalline modification.

Of course, analysis could have shown no difference, for the crystals were still impregnated with the mother liquor. We know now that really a separation of the various silicates is operative in the glass, and that the monosilicate of calcium crystallizes out. Now, if the calcium silicate crystallizes as soon as the glass becomes cooler, it ought to exist in that condition dissolved in the mass. And this again agrees with the hypothesis according to which glass is not a chemical compound, but a solution of a crystalline silicate in an amorphous silicate. At first sight it appears absurd to speak of a chemical formula of glass, but in comparing the famous glass of Venice with that of the best factories of Bohemia, of St. Gobain, and of Chance & Co., of Birmingham, certain analogies present themselves, which Beurath expresses by what might be called the chemical formula of normal glass, $5\left\{\begin{matrix}Na\\K\end{matrix}\right\}O, 3\ Si\ O_2 + 7\ (CaO, 3\ SiO_2)$.

The question may be asked, since devitrification is always on the surface, how does the monosilicate of calcium, being inclosed in a solid body, get there?

It has been said that an atom is never twice in the same place. This may be true, if space be taken in its absolute sense. But even in solids, molecules as well as larger particles of matter enjoy a greater latitude of motion than is commonly supposed.

Boyle, in his tract on "The Languid Motions of Bodies," mentions a turquois in which several spots of different colors were seen moving for many months gradually from one part of the stone to another. Several pictures of these spots, which were made at different times, proved this beyond a doubt.

In a few other turquois stones, two different blues in different parts of the stone were seen to encroach upon each other, until at last they had changed sides completely. Furthermore, Draper observed by analysis that in long buried Roman silver coins much of the alloying copper had come to the surface to form the green patina of antiquarians, and that the silver within was comparatively pure. These motions sometimes go even to change the form of solids, as for instance in plastic ice. But even in solid mineral substances the particles are sufficiently free to move in order to determine sometimes a deformation of the body.

It may be pertinent to mention some cases which have come under my observation. There is exhibited in a museum in London a slab of sandstone, about two feet long and two or three inches thick, which had been supported for some time at its extremities only, and had thereby eventually assumed the form of an arch. A very curious example, which it seems to me comes under the same head, is now in the Soane Museum in London. It is the magnificent sarcophagus which once contained the mummy of Sethos, the father of the great conqueror, Rameses II.

This object, unique in the world, is cut out of a solid block of alabaster, nine feet in length, and so thin that a person could read in it when covered with a lid of the same material, as it probably was, though it has now disappeared. Both sides are slightly deformed, especially one is bent several times irregularly to and fro. This irregularity cannot be accidental. Moreover, the extremities, which were left thicker and are comparatively short, have preserved their perfect geometric form.

Although I have never heard an explanation nor any mention made of this irregularity, but is it not obvious, from what we have already learned, that on account of the extreme thinness of the walls it could hardly have been expected otherwise?

Now, then, in order to return to our question, in glass, too, it cannot be denied, there must be such motions. And since devitrification always takes place on the surface, does it seem to be untenable to suppose that the monosilicate of calcium, too, gains its way to the surface by some such interstitial movement?

Window or plate glass is almost universally made by blowing cylinders. The old method of blowing plates tends to disappear, and is now only used in certain parts of England.

Pittsburg alone has fifteen window glass factories, which produce annually for $4,850,000. The largest cylinders of Belgian manufacture, which were shown last summer in Paris, were 270 by 140 centimeters, or 107 by 55 inches; another measured 310 by 100 centimeters. As a novelty of the exposition in this line of work, may be mentioned Appert's perforated glass. It is plain window glass with 5,000 perforations to the square meter, and may be excellent in many places where ventilation is needed.

The art of making blown plate mirrors, which remained for a long time a secret, is due to the Venetians. Colbert, the great minister of Louis XIV., wrote in 1664 for information to the ambassador of Venice, but in vain. Later on, French workmen went to Venice and succeeded in getting on the island of Murano. Climbing on the roof of one of the workshops, they spied out through an opening the secret of that manufacture. They returned to Paris and established themselves at the Faubourg of St. Antoine, where this process was continued until 1691.

Lucas De Nehon, in that year, invented the method of casting plate glass, and thereupon installed that manufacture in the castle of St. Gobain, which is still the principal center of production of the company. This process, it is said, has saved the lives of thousands of laborers, and has also destroyed the industry of Venice.

Ever since the dimensions of plate glass have constantly increased. In the exposition of 1878 a plate reached twenty-six square meters. This was surpassed, however, in 1889 by a plate of St. Gobain, with a superficial area of 33·16 meters. Its actual dimensions are: For height, 8·01 meters; length, 4·14 meters; and thickness, 0·018 meter. Weight, 1,492 kilos. It would have made a suggestive centennial plate for our country.

According to the latest statistics, the actual amount of plate glass manufactured in Europe is:

France	410,000	square meters.
Germany	300,000	" "
Belgium	300,000	" "
England	800,000	" "

Unfortunately for the United States, we have no reports available. But the growth of this industry in this country is illustrated in a remarkable manner by that of Pittsburg. Established a few years ago, with a capacity of 50,000 square feet a month, it has increased in 1887 to 250,000.

A new factory, erected in 1887 by Pittsburg capitalists, at Butler, will make the total capacity nearly 350,000 square feet per month.

Pittsburg claims to be fully abreast with the world, and that her products in every respect equal and, in some cases, surpass those of France.

Plate glass after casting is always rough, and has to be polished successively with sand, emery, and colcothar. It was formerly done by children and women, whose hands and fingers, in this continuous process of friction, became often fearfully mutilated. All this is now superseded by machines, which, in their motions, produce regular lemniscates.

Much of the plate glass is used for mirrors. They are usually coated with an amalgam of tin. Such mirrors, in tropical countries, or when placed against chimneys, are often destroyed by heat. Silvered mirrors are free from this objection, and are very cheap, but they are slightly yellow and turn black whenever there are emanations of hydrogen sulphide. To render them whiter, a mixture of the cyanides of silver and mercury is often used. Mirrors are also coated with aluminum and platinum; they are unalterable by heat, but their power of reflection is somewhat diminished, and when regarded laterally, appear bluish. The coating of platinum is very thin and gives also excellent sun glasses.

The following table gives a lucid presentation of the progress that has been made in the manufacture of mirrors since the introduction of machines and the application of scientific knowledge to industry:

	Price of mirrors.	
In	1 sq. meter.	4 sq. meters.
1702	165 francs.	2,750 francs.
1802	205 "	3,437 "
1805	226 "	4,008 "
1835	127 "	1,245 "
1862	47 "	262 "
1881	35 "	199 "
1889	—	129 "

The augmentation in 1802, a century later, may be accounted for by the greater value of all commodities. In 1805, on account of the Continental blocus, prices were exaggerated.

Ancient lead glass resembled in its composition strass much more closely than the flint glass of our times. For this we are indebted to England, where it was first made 1635. Since in England coal is employed for heating, which gives much fume, it was necessary to use hooded pots. But thereby the glass melted less easily, and to prevent this inconvenience they conceived the idea of adding litharge as a flux. This, however, changed the properties of the glass entirely. By proper care in the operation and in the choice of the materials, a glass is obtained which is really the most beautiful vitreous substance that can be produced.

For crystal or pure flint glass, carbonate of potassium is always used, and cannot be replaced by the carbonate of sodium, which invariably gives a green tint. Generally flint glass articles, such as tableware, globes, domes, reflectors, chimneys, etc., are small. Some of them are made by moulding, but most of it is blown, and that in enormous quantities. A single firm in Pittsburg, for instance, produces annually 12,000,000 chimneys. It is estimated that for such articles a glass blower blows in a working day of ten hours at least 7,000 liters of air.

Messrs. Appert & Bros. have patented a process of glass blowing by air compressed in steel accumulators. The cubic meter of air costs about one cent, and varies in pressure from 5 to 30 grammes. To show that large objects can thus be blown just as well, they exhibited in Paris a balloon for watch glasses of 1,950 liters. It was 1·55 meters in diameter and weighed 25 kilos.

The blowing of large masses can certainly not be salubrious to workmen, and considering that the blowpipes pass from hand to hand, or rather from mouth to mouth, zymotic diseases are only too apt to be transmitted. Very often inventions which are intended to benefit the working classes find in them their greatest opponents.

Bohemian glass, a purely German invention, contains potash instead of soda, and no lead. It is, therefore, from 30 to 35 per cent. harder to melt and to cut than flint, but is susceptible of a more beautiful polish, and retains it better. Formerly, the materials were in the immediate proximity of the factories. The pots were small, and whenever the wood in the vicinity was consumed, they simply moved and extemporized another workshop at some other locality. At last, wood became so rare that special laws had to be passed for the protection of forests.

Toward 1870, soda was introduced. The article employed was very pure, and even a little of minium was added, which gave great brilliancy to the glass. Bohemian goblets are very fine and delicate, and have for a long time been remarkable for the thin bottom and no pontee. Ordinarily, in making such goblets, a little boy comes forward with an iron rod, the pontil, on the end of which has been gathered a small lump of metal, which is pressed against the base of the goblet; it adheres, and is then finished. This always leaves a roughness at the bottom of those objects.

American manufacture differs in this respect, and Europeans at the last centennial exhibition were surprised to see all American glasses without pontee and perfectly smooth.

Formerly all glass in Bohemia was cut, but they have recently learned what excellent results are obtained in this country by the process of moulding, and American moulds are now employed to great advantage.

Differently colored layers of glass are often superposed, and thus it may be doubled, trebled, and quadrupled. By removing some of these layers entirely, or in part, splendid effects are produced. In this kind of manufacture the Bohemians take the lead; and excel both in design and in the art of coloring.

Engraving on glass also originated in Bohemia. There are entire villages, such as Hayda, Steinschonan, and others, with populations of more than 25,000 workmen, who devote themselves exclusively to engraving on the wheel, or with acids, to painting, gilding, and other fancy work. In all these places are special schools where they educate their own artists.

Imitations of precious stones are made near Gablonz. For this purpose strass, a material named after John Strasser, of Vienna, is employed. It is made in small quantities at a time, only about 40 or 50 kilos per crucible. Among the 5,000 laborers of that locality, even children of five or six years are occupied in polishing those gems, so remarkable for their aspect. The wages paid are, for men from 18 to 26 cents a day, and for children from 6 to 10 cents.

No substance lends itself at the same time more easily, better, and more lastingly to all imaginable colors than glass.

According to Pliny, however, colorless, transparent glass, that which resembles rock crystal most closely, will always remain the most highly esteemed. We admit that in ornamentation even gold on crystal is but adding the brilliant to that which shines, and therefore a pleonasm. But for all that, we now could not well do without the material wherein Roman workmanship excelled so much that modern art appears to be powerless to imitate objects like the vase of Barberini, which adorns the Museum of Naples.

Another example is the celebrated Portland vase, which, among connoisseurs, for a long time has passed for engraved stone. Numerous imitations have been attempted. One of these which figured in the English section in the exposition of 1878 was still unfinished, but represented already an expense of 62,500 francs.

Glass is colored either in its entire mass or by flashing. Both methods were known to the ancients. The colors and gamuts of colors which can be obtained with different oxides are unlimited in number. For equal quantities of oxides colors are more intense the more the glass is basic, and less the more it is acid. Difference in color also depends on the degree of oxidation of the oxides, on the degree and duration of the temperature to which they are submitted, and finally on the base of the glass, whether sodium, potassium, or lead.

To color glass, three methods are adopted. By the method of addition the oxide is first melted in borax and then added to the liquid glass. By the method of cementation, which is used for silver, gold, and platinum, the chlorides of those metals are formed into a paste with ferric oxide as a medium, and thus painted on glass, which is then heated to redness. The last method consists of reheating the object which contains already the coloring substances.

Manganese gives beautiful colors. If the glass contains soda, the violet is reddish, and with potash it is bluish. Green is obtained with the oxides of copper, chromium, and the protoxide of iron. Large quantities of the oxides of copper and cobalt or of ferric oxide give black, but the most beautiful black is obtained with sesquioxide of iridium. Silver chloride gives a brilliant yellow. Yellow rays produce effects comparable to sunlight. A room thus papered is always light and cheerful, and often a yellow window produces the same effect.

Experiments on this subject have been made in hospitals, where it seems to have produced a more cheerful disposition in patients. Yellow lights are often used in dark naves in many churches in Europe.

A remarkable sight is the tomb of Napoleon, where, against a window of yellow glass, there is placed a huge black cross, with the effect of making it appear to be aglow with a living fire, even long after the sun has set and all is shrouded in darkness.

Enamel is a vitreous substance which may cover any material, but most usually earthenware. It may be regarded as a colorless glass, which holds in suspension an opaque, insoluble body. Stanniferous enamel was introduced to Europe by the Arabs. For a long time that was the only kind of enamel known, but now we have enamels which are transparent, opaque, colorless, and colored.

Iron is enameled by cleaning it first with sulphuric acid; the surface is washed, dried, and the enamel in form of powder is put on the object, which is then heated to redness.

On glass, very pretty designs are obtained by the use of paper or lace patterns. They are put on the surface to protect it, in places where no enamel is desired, against the fine enameling powder, which is blown over it. The patterns are removed and the glass is then heated.

To produce designs equally durable, but of a different nature, sandblast is used, a process which was discovered in 1870 by Tilghman, of Philadelphia. The ancient method of etching glass, which was known al-

ready in the seventeenth century, has only recently come in vogue for the decoration of glass.

Astonishing results can be obtained with glass of differently colored layers, if they be skillfully removed. Thus, on doubled glass, actual paintings of flowers and fruits have been obtained in eight different tints.

In all countries where the sun shows itself discrete, and where humidity is excessive, paintings on walls, however costly they may be, are soon condemned to disappear. Mosaic art is the only means of preservation. At present there are only three establishments in existence where this art is officially encouraged, namely, the Vatican, St. Petersburg, and Paris. As private enterprise, however, Florence and Venice are also famous.

Unique in this respect is the dome of St. Marcus, where the surface covered with mosaic is more than 4,000 square meters. Artists are never embarrassed for lack of color, but rather with the difficulty to perceive a difference, for, as Salviati affirms, there are in this art more than 30,000 shades of colors.

Another industry where the art of the painter is almost indelibly impressed against the inclemencies of time is that of staining glass. It has been observed that the ancient windows of cathedrals are richer in color and more brilliant than those of modern manufacture. The reason of this has been recently explained by the aid of the microscope. On account of the ceaseless attack of temperature and moisture, these panes have been chiseled into innumerable points, where each ray of light by interference is refracted and reflected a thousandfold.

A lesson has been taken from this, and now similar effects are produced artificially by roughening the surface of glass as much as possible.

Among smaller objects of art the manufacture of glass beads has at one time been of importance, but in its more artistic form is now principally relegated to Venice. Large beads are always blown, but the common small beads are simply cut with knives from bundles of glass tubes. Being mixed with powdered lime and charcoal, the openings soon fill up. They are then heated until the ends become round, and when cool, are freed from the impurities by washing with dilute acids.

Native pearls have always been high in value, and therefore a favorite subject for imitation. Cleopatra is said to have eaten a pearl of enormous value dissolved in vinegar. Pearls sometimes die, that is, they lose their luster. Usually they are silvery or bluish white, hard, smooth, and lustrous. In form they are roundish, more or less regular. They are generally found in the shells of several species of mollusks, particularly in the pearl oyster. Composed of calcium carbonate and interstratified with animal membrane, they appear to be the result of a diseased secretion, caused by the introduction of foreign particles. Sometimes pearls are very fragile.

My teacher once related that a certain gentleman put several pearls into his hands, but on hearing that each was worth about 10,000 francs, he kindly asked to have them removed.

Pearls are imitated with opalescent glasses, but best with a liquid consisting of the scales of ablets, which are abundant in Germany. About 20,000 of these little fish are necessary for one pound of Oriental essence, as it is called. Imitations with this are so perfect that the jury of the Paris exposition in certain cases was unable to decide.

In 1877, Fremy and Feil have been able to prepare rubies and sapphires artificially and sufficiently large to be of use to watchmakers and jewelers.

Among particular industries might still be mentioned those of watch glasses and optical glass. Watch glasses are made in several ways. Sometimes by cutting them out of large balloons with a diamond, which is moved by some machine. Often these watch glasses are removed from the surface of the sphere carefully so as to leave the skeleton intact, which by itself looks as windy as a chateau en Espagne. Also by cutting round plates from plain glass and heating them in cups, whose forms they finally assume. They are also made by pressing the hot glass plate into moulds with carbonized cork wood, or, finally, by direct moulding. There are sixteen different classes of watch crystals. The first class contains already 6,912 different kinds. Under these complicated circumstances competition is almost impossible, and in this respect similar to the manufacture of buttons and needles.

In 1827, Faraday and Herschel were appointed by the English government to experiment on the manufacture of optical glass. A special furnace was constructed, and after spending about $30,000, the experiment was abandoned, with Faraday's glass for a result, which has a specific gravity of 5·44.

The objective of the great telescope of the Lick Observatory on Mt. Hamilton, in California, rough three feet and three inches in diameter, was made by Feil in Paris.

In the working of such large masses of glass, stirring up in order to produce homogeneity is the principal condition for success. It is often done with a rod of platinum. When the block is finally taken from the crucible it is laid on a proper mould, where it is heated, until, in spreading out, it will fill it. The heating is continued for ten or fifteen days, and then the mass is allowed to cool for a month or more.

Feil is recognized to-day by all astronomers as the first manufacturer of optical glass. There was at that time but one place in the world where it could have been made, and but one where it could have been polished, and that was America.

We have seen how this beautiful and noble industry, which lends itself to the necessities of man, material as well as scientific and artistic, has changed its abode of supremacy with the destinies of nations.

If in marshaling our evidence we would follow once more in the footsteps of this industry, we would see that from the time of the simple glass blowers of the hypogeum of Beni Hassan down to our modern artists, embarrassed by an infinite complexity of processes, the supremacy of this noble and useful art has passed down among the peoples of the earth in chronological order of their highest development. We have seen how it passed from the Eyptians to the Arabs, to the Greeks and Romans, then during the fourth century to Constantinople, which at that period was the most luxurious capital on the face of the earth, and then to Venice.

There, on the island of Murano, were resuscitated the processes of the Greeks and Romans, who themselves were but the disciples of the Egyptians.

Finally, we saw how it passed to the Bohemians, who instructed the French, and they in their turn the English. But, now, if history is to be our judge, as it evidently ought to be, we must see that a great future is just opening before our eyes.

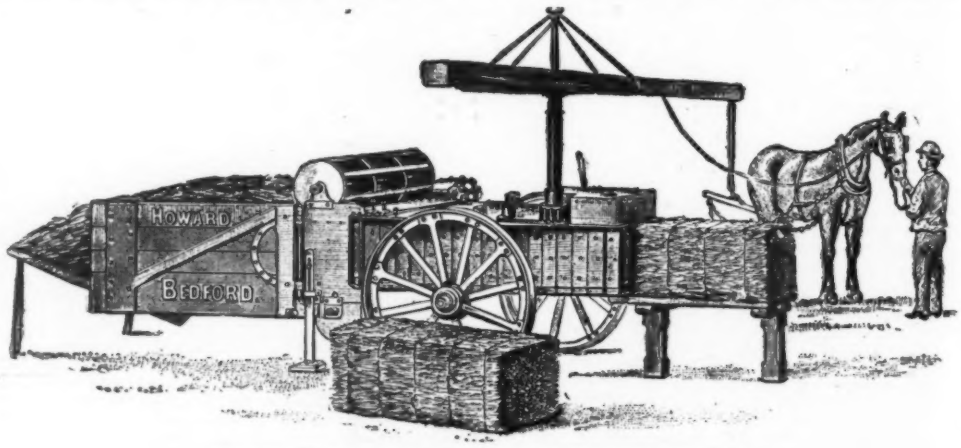
As a nation, we are already first in agriculture, in mining, in the packing and exportation of meat, in the industry of milling and exportation of flour, and first even in the manufacture of iron. What greater industry could now be added more appropriately to all these to heighten and strengthen the fame and prosperity of our country than that of glass?

Europe is at a standstill and lives on the capital of her past greatness. Therefore, supine to whatever may be reserved for us, we ask at least where will in the future be its uncontested supremacy?

May I here be allowed to repeat what I have once said on this subject in a lecture in Pittsburg, situated as I was on the promontory between the Monongahela and the Allegheny, in the midst of the ponderous throb of cyclopean industries? And now, what shall I say of this industry in our country? Of its humble beginning, I will not speak, and in proof of its present gigantic development, we have before our eyes thousands of glowing furnaces. It seems to me this industry will prosper among us and will prosper for a long time, for it loves to dwell in the shade of a great nation.

IMPROVED HAY AND STRAW PRESS.

AT the late Smithfield show, the hay and straw baling press of Howard, of Bedford, was shown, adapted for being worked by animal power where steam power is not available. The machine thus improved is here illustrated. When working in combination with a steam threshing set, the press takes only from 1½ to 2 horse power, the power required being uniform and not intermittent. The straw falling from the shakers passes through the press and is delivered in bales at the rate of 1¾ tons per hour, with a density of 9 lb. per cubic foot. A bale measuring 18 inches square at the ends and 33 inches long weighs 56 lb. Loose hay is baled at the rate of 2 tons per hour.



IMPROVED HAY AND STRAW PRESS.

RABIES AND ITS PREVENTIVE TREATMENT.*

By ARMAND RUFFER, M.A., M.D.

DURING the last four years—that is, since the publication of Pasteur's researches on the antirabic treatment as applied to man—many and important papers have appeared on the subject which is to occupy us to-night. The critical minds of medical men, always anxious to test the truth of any so-called discovery, seized on M. Pasteur's statements and submitted them to the rigid test of experimental criticism. The political press, likewise wishing to give its readers the latest news, published more or less accurate information concerning the mode of treatment followed at the Pasteur Institute, and also reproduced letters from a large number of persons who wished to air their opinions about rabies.

In this country, during the course of the year 1889, much has been spoken and written about the disease. I need only refer to Sir Henry Roscoe's bill for the compulsory muzzling of dogs, to the speeches made on July 1 at the Mansion House by many eminent men, to Mr. Kerslake's paper before the Balloon Society, and to M. Pasteur's contribution to the *New Review*. I cannot be expected, therefore, to raise any very new points, and indeed I would not have ventured to speak here to-night if I had not been requested to do so by your secretary, at the suggestion of some of my scientific friends. He asked me to do so simply because he knew I had had many opportunities to see rabies in man and animals, and to watch during several months the immediate and remote effects of the antirabic treatment.

In this paper I shall not attempt to give a *resumé* of all that has been written on rabies, for the literature on that subject is so large that the mere enumeration of the remedies which have been used against it would occupy more than the time at our disposal.

I must limit myself to giving an account of the nature of the disease. I intend to indicate the means at our disposal to eradicate it, and lastly to show how its occurrence may be prevented in human beings, even if they have been bitten by rabid animals.

Rabies is a specific infectious disease, and like all other specific diseases, its first origin is unknown. We do not know how and why the first animal or man who presented the signs of rabies was afflicted with the disease, just as we do not know how small-pox or measles originated. What we *do* know is that nowadays it never occurs spontaneously, that whenever and wherever human beings or animals show the typical symptoms of the disease, the origin of the affliction may be traced to the bite of a rabid animal or to the accidental introduction of rabic virus through a scratch or cut.

If that is so, it necessarily follows that if it was possible to find a place—an island, for instance—where rabies has been efficiently stamped out, no cases ought to occur in that place unless the disease be imported by a rabid animal. That is indeed the case. It is not to be met with in islands, whatever their size may be, in which it has once been efficiently stamped out, and in which dogs are brought on shore after having been kept in quarantine for a period of time of several months. And that is the case whether the island be situated in tropical, temperate, or cold climates. But whenever and wherever (in a country in which there is but a single case of rabies) dogs are allowed to roam at large—especially unmuzzled—or where many wild animals, such as wolves, are afflicted with the disease, cases of rabies must occur in men also.

Climate seems to have no, or very little, influence on its production. It has appeared among dogs in an Arctic expedition, it is common in our countries, it is found in the East, on the coasts of Africa, in Brazil, in India, in China, and broke out with frightful malignancy when accidentally introduced at the Cape. Statements that it does not occur in the east of Europe have been often made, and it seems strange that in a place like Constantinople, where dogs roam unmuzzled about the streets, the disease should be unknown. Unfortunately it is totally untrue, and so numerous are the cases of rabies occurring among human beings in that town, that his Majesty the Sultan, in 1887, endowed an institute for the treatment of men bitten by rabid animals.

Heat and thirst have been supposed by many to have some influence on the production of the malady. That heat has little to do with it is shown by the fact that rabies occurs in cold as well as in hot climates. In temperate climates, cases occurring among dogs appear to be as common, if not more so, in the winter than in the summer. I have been able to get confirmatory evidence of this fact in the following way.

At the Pasteur Institute, in Paris, patients come to be treated from France, England, Belgium, and Portugal, after having been bitten by rabid animals or animals supposed to be rabid. I have, from the accurate records kept at the institute, prepared a diagram showing the number of human beings who presented themselves for treatment during the years 1887 and 1888. In order to insure greater accuracy, I have carefully excluded all patients bitten by animals in which the disease had not been proved to be present, either by the test of inoculation or by a veterinary surgeon's certificate.

If you look at the diagram on the wall, you will see that 56 per cent. of all cases occur from December 1 to June 1, and 44 per cent. from June 1 to December 1. Notice also that the highest number in both years came to the institute in February, and the lowest in November, and that comparatively few patients were bitten in June, July, and August. I think we may conclude from these diagrams that, in late years, the chances of being bitten by a rabid animal are certainly as great in the winter as in the summer.

Cruelty as a cause of rabies may also be excluded. That ill-treatment may cause even a good tempered animal to become vicious, or that a dog after being goaded to fury will turn on its master and bite him, is true enough; but that animal is no more rabid than is the negro slave who brains his master with a club. There is not a particle of evidence to show that ill-treatment will produce rabies. Cruelty to a dog will no more give rise to the disease than ill-treatment will produce small-pox in a human being.

The chief propagator of the disease, in this country at least, is the dog. This animal, when the first symptoms make their appearance, does not always present the symptoms which to most people are characteristic of rabies. It usually is not afraid of water, and instead of showing signs of fury, the first symptom is at times an increase in the affectionate sentiments of the animal. The dog does not bite his master at first, but will often lick its owner's hand or face, or even other dogs it comes across.

Even, then, however, the saliva of the animal already contains the virus, and I have seen a man die of rabies after having been licked on a sore place on the hand by his own dog. Later on it often becomes sullen and morose, with a very characteristic bark, biting other dogs it comes across; frequently runs away, snapping at animals or men as it meets them, until exhausted it dies in a ditch or field, sixty or seventy miles from home

* A paper recently read before the Society of Arts, London. From the *Journal*. Sir Joseph Lister, the chairman, in introducing Dr. Ruffer, said that as a member of the Parliamentary committee it was his business to sift very carefully the evidence which M. Pasteur brought forward in support of his preventive treatment of rabies, and the result with him, as with every member of the committee, was that he was thoroughly satisfied on the subject. He had also visited the Pasteur Institute, and had seen with admiration the perfection of the equipment of the institute, and the thoroughly scientific manner in which the operations were conducted. He also knew M. Pasteur's kindness of heart, and his especial tenderness toward suffering, whether in man or in the lower animals. Dr. Armand Ruffer was specially well qualified to speak on this subject, from his long and intimate acquaintance with the working of the Pasteur Institute, and he had much pleasure in calling upon him to read his paper.

sometimes. If that be the ordinary or popular form, the other variety, or dumb rabies, characterized by the symptoms of paralysis, is not less common and just as dangerous; for many are not on their guard against it, and may unwittingly expose themselves to contagion. The virus is the same, but gives rise to different symptoms. This is proved by the fact that an animal with furious rabies biting another of the same species may produce dumb rabies in its brother.

In Russia and other countries where wolves are numerous, rabies is often propagated by these animals also. A rabid wolf during the furious stage of the disease is a most terrible animal to meet. One of these brutes, when suffering from rabies, occasionally gets into a village during the day and bites every animal or human being it comes across, attacking sometimes as many as sixty or seventy persons in one day. The bites are extremely severe, for, unlike the dog, which often gives a snap only and then passes on, the wolf sticks to its victim, bites and worries it so relentlessly that it is not rare for these poor people to die from their wounds on the same or next day.

Rabies is occasionally met with in foxes, horses, sheep, pigs, and cattle which have been bitten by other rabid animals, but the cases in which the disease has been communicated to human beings by such animals are extremely rare. Lately there have been two epidemics of rabies among deer, one at Richmond and the other at Ickworth in the park of the Marquis of Bristol. During the latter epidemic, my friend, Mr. Adami, accidentally inoculated himself with the virus, but as I see him here to-night I will not say anything more about it, for I hope that he will presently give us his experiences of the disease.

The domestic cat has been known to communicate rabies to man. A rabid cat, however, is not nearly so dangerous as a dog afflicted with the same disease, for the former hides away in some dark place, and only throws itself on animals and human beings when these come too near to disturb it. The dog, on the other hand, runs through large tracts of country, and thus becomes the common carrier of the dread virus.

The signs of the disease in man have been accurately described by many competent medical men, but the popular notion as to the symptoms are very vague and erroneous in many points. The popular description of a human being suffering from rabies—or hydrophobia, as it is sometimes called—is that of a violent madman, barking, howling, and trying to bite. As a matter of fact, in many cases the patient is perfectly calm and conscious, and the attacks of excitement are rare. The public does not recognize the fact that the patient foams at the mouth merely because he is unable to swallow his saliva.

The voice becomes hoarse and changed in character on account of the dryness and spasms of the throat, so that the cries of such a patient sometimes resemble, in the very vaguest manner, the barking of a dog. Further, a patient thus afflicted will occasionally bite the attendants during a paroxysmal attack of fury, just as any other patient suffering from ordinary acute mania may do so, but, in the large majority of cases, he does not try to injure those near him, and hardly ever tries to bite. The patients sometimes have no attacks of excitement whatsoever, and the affectionate sentiments are then often greatly exaggerated; the patient crying takes leave of friends, bemoans his fate and lastly dies exhausted. In fact, one of the most painful sights it was ever my misfortune to witness was that of a young girl of eighteen, in the last stage of rabies, taking a final farewell from her friends.

Popular imagination had been struck by one symptom, namely the fear of water, or hydrophobia. Many had noticed that a rabid dog is often totally unable to drink, and that the face of a rabid human patient betrays all the signs of fear and horror whenever he sees water, or even hears the sound of falling liquids. From times immemorial the public—physicians even—have given to diseases the name of one of their most striking symptoms, and we need not wonder then that the words "rabies" and "hydrophobia" have become synonymous. This is, nevertheless, based on error, for although a rabid dog is not able to drink, it does not fear water as a rule. The human being likewise shudders at the sight of fluid, because it gives rise to most painful spasms of the throat, though in a few cases the patient has no fear of water at all, and is able to drink right through the course of the disease. Lastly, the form of rabies in which paralysis is the chief symptom, unknown to the general public, was but little studied by physicians.

This mere sketch of the symptoms will certainly suffice to show you that this malady is a most interesting and terrible one. Another reason which adds to the fear with which the public regard this affliction is the fact that a human being, bitten by a rabid animal, remains for weeks, months, and even years in a state of anxiety and suspense concerning his fate. The majority of persons, namely ninety per cent. of those who do perish after the introduction of the poison, die within four months, and more than ninety-nine per cent. within the year. The cases dying more than one year after the bite are extremely rare, as the diagram on the wall shows. These unfortunate patients, however, know that if once the first symptoms of the disease make their appearance, they are doomed to a certain death, and although cases of recovery after the appearance of the first symptoms have been described, I confess that I have been unable to satisfy myself that a human being who has once shown some definite symptoms has ever got well. Cases of recovery in dogs undoubtedly do occur.

And yet an account of the remedies against rabies, which have been lauded by their discoverers, would fill the pages of a good sized volume. Celsus, living in Caligula's time, stated that the best way of curing a patient afflicted with rabies was to throw him into a swimming bath. This treatment was extolled by almost every author through nearly eighteen centuries, until Morgagni showed how useless it really was. Others advised the bitten man to eat the liver or brain of the animal which inflicted the wound. During the middle ages, and even now, the chapel of St. Hubert, in the Ardennes, is a place of pilgrimage to which people bitten by rabid animals still proceed. The patients at St. Hubert (according to the "Revue Encyclopedique") are told that they are not to change their linen, that they must always eat from the same plate, drink no white wine, not look into a mirror, always gaze straight before them when taking their walks abroad, and not wash themselves. This treatment lasts forty days. In Italy, the keys of a church near Rovigo when touched are also supposed to prevent the occurrence of rabies in patients bitten by rabid animals, and the same supposed curative power is also attributed to the keys of St. Guilterie, St. Roch, and St. Pierre de Bruges.

The treatment by Turkish baths, reintroduced by Bouisson, is by no means new, for it was described by Celsus, and also by Dioscorides. I need not tell you that this mode of treatment is absolutely useless, for my friend, Mr. Horsley, in 1888, showed that the notion on which it is based is utterly fallacious, and further that animals so treated after having been inoculated with rabies, die even quicker than others in which the disease is allowed to run its own independent course.

Of the number of drugs which have been tried to prevent the occurrence of rabies, or to cure it when the symptoms have made their appearance, I need not give an account. Shortly stated, there is no drug which cures the disease, though much may be done by narcotics, such as chloroform, chloral, and morphia, to alleviate pain, and render death more easy.

Cauterization or sucking of the wound have been said to prevent the occurrence of rabies in patients so treated. I am quite at a loss how to form an opinion on that point, for the reason that I have been unable to find any reliable data on which I could base a belief in their value, the statistics given by various authors being quite unreliable. Judging from personal experience, I feel inclined to doubt the value of cauterization, for among the human beings I have seen die of rabies, were two who had been carefully cauterized by medical men very soon after the wound had been inflicted, and of three persons I know, bitten by the same rabid dog, the only one who died was the one who had been cauterized immediately after the bite. Such then being, roughly speaking, our knowledge of the chief phenomena of this affliction, let us see what can be done to put a stop to the spread of the disease and to prevent its occurrence, when a human being has been bitten by a rabid animal.

When discussing the spread of rabies among animals I showed you that the dog, in this country at least, was the chief propagator of the disease, and that if it were possible to destroy the virus now living in some of the dogs of this country, the disease would be practically stamped out of England, as it never occurs spontaneously. The virus, unlike that of other diseases, has the peculiarity that it will not thrive outside the living body. Every physician knows that the virus of scarlet fever, for instance, will hang about the clothes or the room of a scarlatinal patient for days, weeks, months, or even years, unless these objects or localities be thoroughly disinfected. Again, an animal dying of anthrax, if simply buried in a field, does not for that reason become harmless. The soil, the water, everything touching the dead carcass of that animal becomes contaminated, and months, years afterward, a bullock or sheep grazing over the grave of its fellow may become infected by the anthrax virus brought to the surface by the laborer's spade, through the action of earth worms or through some other means. It is not so with rabies, and it is lucky that this virus dies so very easily, for if it had the same resisting power as that of anthrax, it would be the most frightful scourge to humanity. On the contrary, it does not retain its vitality for any length of time after the animal carrying it is dead, but a few days, or one or two months at most, after the death of the animal, it perishes also. Similarly, again, the virus contained in the saliva dribbling from the mouth of a rabid dog, or present in the dejections of the animal, dies in a very short time—as soon as sunlight and dryness have acted upon it.

What then are the measures which must be adopted to stamp out the virus among the dogs alive at this present moment? I may assume that you are strongly opposed as I am to all such measures as wholesale destruction of dogs by poisoned meat, or as filing their teeth, measures which have been proposed in this century even. I think there are only two regulations which are of any use whatsoever.

1. The registration of all dogs, and the wearing of a collar by each dog, with the name of the animal's owner engraved on it; all dogs not wearing such a collar to be at once destroyed.

2. The destruction of all stray dogs, and the muzzling of all others, together with quarantine for all imported dogs.

Of the two, the first must be considered, if applied alone, as inefficient, because it will not prevent dogs in the first stage of rabies from biting other dogs. Remember that, before the actual typical symptoms of rabies have made their appearance, when the unfortunate animal's condition is often betrayed only by an exaggeration in its affectionate sentiments, a dog is already dangerous and its bite will produce rabies. If that animal be allowed to go about unmuzzled in the streets, it may infect others before the disease is diagnosed. Further, in countries such as Belgium, in which it has been tried, registration of dogs has proved powerless to arrest the disease.

The muzzle certainly prevents contamination during the early stages of the disease at least, and in some cases even when the more prominent symptoms have made their appearance. It has been said that a rabid dog always gets off, and that accordingly the muzzle would not be of any use, because it would run away without it. That to some extent is true, but it is not always so. To give you an example—and Mr. Millais will contradict me if I exaggerate, for he also knows the facts of the case—I will mention the case of a dog suffering from all the acute symptoms of rabies, which was brought unmuzzled by its mistress in the train all the way from Bangor, in Wales, to London, was led through the streets of London from the station to Wandsworth, where it finally died.

The owner, a lady, stated that during its progress it did not bite anybody, but as she confessed that it rushed at every living being it came across, and bit her in the hand, I think we are justified in doubting the truth of her statement. Now that dog, under an efficient muzzling act, could not have done any mischief, because it must have been brought muzzled through the town. But, in his masterly paper read before the Balloon Society, my friend Mr. Kerslake has so well stated every argument which can be brought forward in favor of muzzling, that I must refer you to his paper for further information. He has conclusively shown that whenever and wherever muzzling has been efficiently carried out, the deaths from rabies have become fewer, or are even totally absent. In England the circumstances would be very favorable, because the country being surrounded by water no stray dogs can come in from parts where muzzling is not enforced, and because there are no wolves and hardly any other wild animals to propagate the disease *de novo* if once efficiently stamped out in the canine species. Muzzling, to be efficient, ought to be enforced on all dogs throughout the country, though it must not be forgotten that even local muzzling will do something to stamp out the disease. In Paris a muzzling order was efficiently carried out during three months, and the number of people bitten came down from 67 to 19 per month at the end of that period.

I said that destruction of all stray dogs must be enforced at the same time. The ownerless dogs wandering about the streets must, of course, be more frequently exposed to bites from rabid animals. In many countries they are seized by the police and brought to some place where, after being kept for some time, they are destroyed, or, if valuable, sold. Now, every dog which has been roaming about the streets may have been bitten by a rabid animal, and, if not to be destroyed, ought to be kept under observation for a period of time long enough to exclude all chances of rabies making its appearance, should it, while at large, have been inoculated with rabies. In my opinion, therefore, every dog unclaimed by its owner ought to be destroyed, unless it be completely isolated from other dogs for a period of at least six months before being sold.

At present, however, there is still a chance of some of us here to-night being bitten by rabid animals, and if I mistake not there are at least two persons in the room who have been so bitten. I think what most of you would like to ask me is this—"Suppose you had been bitten by a dog, and the veterinary surgeon had told you that the animal was rabid, or suppose you had been bitten by a stray dog you thought was rabid, what would you do?" That, I think, is the practical—the patient's—point of view.

To answer that question it is necessary to know what the mortality really amounts to among persons who have been bitten by rabid animals, and who have not undergone any preventive treatment.

In the case of persons bitten by rabid domestic animals, the mortality has been variously estimated. Faber has tabulated the cases of 145 people bitten by rabid animals in the kingdom of Wurtemberg, and he found that the mortality amounted to 19 per cent. At the general hospital in Vienna, in 1860, it was found that of 115 persons bitten by rabid animals, 25 died (mortality 21·73 per cent.) Leblanc states that of 32 people bitten by dogs undoubtedly rabid, five died (mortality 15·62 per cent.) During the year 1887 forty-four people bitten in Paris by rabid animals declined to undergo M. Pasteur's treatment, and seven of them died (mortality 15·9 per cent.) Other statistics show a mortality varying between 20 and 50 per cent., but these numbers are probably too high, because they are derived from official reports, the officers of the state being more likely to know of the fatal cases than of those which ended in recovery, and I shall, for the sake of argument, assume the mortality to be 15 per cent., although I believe this number to be somewhat too low.

The statistics of the Comité d'Hygiene from 1862 to 1872 show that of people bitten on the face 88 per cent. died (50 cases), on the hands 67·25 per cent. died (113 cases), on the upper limbs 30 per cent. (40 cases), on the lower limbs 21·21 per cent. died (33 cases), on the trunk 31·81 per cent. died (22 cases), on the face and hands two men died out of eight persons bitten.

In the case of wolf bites, the statistics of Renauld, Vallet, Du Mesnil Bombarda, Gamaleia, and others, comprising together 1,296 cases of wolf bites, show a mortality of 60 to 64 per cent. Thus, for instance, one wolf at Ewanguliezenvic, in Russia, bit 35 men and 23 women. The wounds were cauterized with caustic potash, but, nevertheless, 24 men and 15 women died (mortality 67·24 per cent.) within six months.

I shall again assume the lowest figure to be correct, and the mortality from wolf bites to be 60 per cent.

Let us now see the results which M. Pasteur has obtained by his treatment, but first let me say a few words concerning the mode of production of the virus which is used for inoculation, as I find that some errors on the subject have, unwittingly, no doubt, found their way into the daily papers.

When in 1880 M. Pasteur began to study rabies, he had already published several other discoveries concerning preventive inoculations in other diseases. He had been able to inoculate against the bacillus of anthrax, against the cholera of fowl, and against swine fever, every one of these diseases being due to micro-organisms. It was easy to obtain the vaccinating matter or modified virus for these diseases, because the micro-organisms which are the cause of the disease can be grown outside the animal's body, in gelatine or beef broth, just as potatoes may be grown in a field; and may then be bottled up, just as claret may be bottled up in a flask. He was convinced that rabies was due to a like micro-organism, but all attempts to see or to cultivate it had proved fruitless. He was obliged, therefore, in order to get a supply of virus at all, to inoculate animals, just as public vaccinators inoculate calves to obtain the vaccine matter against small-pox. After many attempts, however, he found that if the virus of rabies be inoculated under the membrane covering the brain of a rabbit, the animal always dies of rabies, and since that time rabbits only, and not dogs, as has been inaccurately stated, are always used for the production of the necessary virus.

Let me tell you how the operation is performed. The rabbit is first chloroformed. Then, a small incision, about half inch long, is made on the top of the head; a disk of bone, the size of half a threepenny bit, is removed, and two drops of the virus injected through a very fine needle under the membrane covering the brain. The wound is sutured and carefully washed, the whole operation lasting less than two minutes. The animal is placed back into its cage, and after the effects of the chloroform have passed off, in a space of time not exceeding ten minutes, one may see it feeding and hopping about as if nothing was the matter. Six to seven days afterward the first signs of the disease appear. This is marked by paralysis, which gradually increases until the animal dies. It suffers

no inconvenience from the wound, as, owing to antiseptic precautions being taken, this never inflames. The whole course of the disease in the rabbit is a remarkably painless one, the animal showing no signs of pain. I may be allowed to state that I have frequently taken not only medical men, but other friends, clergymen, and even ladies, to see these animals, and that all of them have been convinced that there is not the slightest cruelty in the whole process.

After the death of the animal, the spinal cord is taken out, and the virus it contains gradually weakened by drying, until ready for injection. The inoculations in man are made into the skin of the abdomen, but as I see one here to-night who has undergone the whole process, I will let him give you an account of the immediate and remote effect of the treatment.

In this month's *New Review* will be found an account of how M. Pasteur was led to apply this method to man, and I will therefore pass on at once to the practical results of M. Pasteur's inoculations.

(*To be continued.*)

THE GREAT NEBULA IN ORION.

By WILLIAM H. PICKERING.

SINCE its earliest discovery this object has occupied a prominent place in the literature of astronomy, but it is only within a few years since the recent applications of photography that an adequate means has been found properly to represent its structure. As this object is now in its most favorable position for observation, I take this opportunity to describe some of our more recent results, hoping that others may confirm them the present year.

We have lately photographed the Trapezium, showing all six stars very clearly. Their unequal magnitudes make this a very good test object, and I think that no one should feel that he is getting the best results if his instrument will not show the sixth star well separated, and the fifth, which is decidedly fainter than the sixth, clearly defined. For this class of work an enlarging apparatus should be attached to the telescope.

We have recently considerably extended the nebulosity about θ by giving longer exposures, and using a quicker lens. The connection with c is now well marked, while the long nebulous streak extending southward from ζ is broadened and joins c upon the other side, connecting the sword handle with the belt. This extension is of much greater area than the other two nebulæ combined. Its northern portion as far as 30° 30′ S is fairly conspicuous, and makes an excellent test object, not of the instrument or the steadiness, but of the clearness of the air and the blackness of the sky. Owing to the recent advances in stellar photography, this matter of sky illumination has assumed considerable importance, and it is very doubtful if any of the fainter nebulous extensions here described can be photographed at any observatory located in or near a large city. This is due undoubtedly in part to the gas, but chiefly to the electric lights, which illuminate the slight haze found in the sky of nearly all localities with an almost imperceptible light, but which is nevertheless very destructive to the fainter detail shown by our most sensitive plates when used with long exposures. The difficulty is analogous to the impossibility of photographing the solar corona without an eclipse, or of photographing the zodiacal light during an eclipse.

An interesting structure brought out upon our plates is a large spiral nebula whose outer extremity starts in the vicinity of γ Orionis. It passes about four degrees north of ζ, extends to thence to β, then north to η, with an outside stream lying nearly north and south, and preceding B about four degrees. Another stream lying nearly east and west precedes η about the same amount. This nebula is about seventeen degrees in length, by nearly the same breadth, and surrounds a cluster of bright stars, including the belt and sword handle, and extending toward γ. The region containing the nebula is noticeably lacking in stars brighter than the eighth magnitude, but contains the very bright stars γ and B. It is possible that a plate with double our present exposures, which we are soon going to try, will fill the space between η and ζ, thus making the great nebula the inner termination of the spiral. This nebula is shown by three different exposures and is very distinctly marked.

All the above described negatives were taken at our California station upon Wilson's Peak (altitude 6,250 feet). Those showing the nebulæ were taken with a Voigtländer portrait lens of 2·6 inches aperture and 8·6 inches equivalent focus, with an exposure of three hours. Stars eleven to the twelfth magnitude are well shown. A more detailed account of these observations with illustrations is in course of preparation, but will probably not appear in time to be of use to observers this year.—*Sidereal Messenger.*

A SINGULAR METEORITE.

A METEORITE of special interest to chemists has been examined by M. Stanislas Meunier. It fell at Mighei, in Russia, on June 9, 1889, and it was evident, from a cursory inspection, that it was of a carbonaceous nature. In external appearance it exhibited a deep greenish-black color, relieved by numerous small brilliant white crystals; the surface was considerably wrinkled, and blown out into swellings. The material was very friable, and readily soiled the fingers. A section under the microscope was observed to consist largely of opaque matter interspersed with crystals of a magnesian pyroxene and peridote. Fine particles of metallic iron and nickeliferous iron were readily collected by a magnet from the powdered rock having all the characteristics of meteoric iron. The density of the meteorite was not very high, 2·495. About 85 per cent. of the rock was found to be attacked by acids, the portion so attacked being shown by analysis to consist mainly of a silicate of magnesium and iron having the composition of peridote. On the remaining 15 per cent. being heated in a current of dry oxygen gas, it readily took fire and burnt brilliantly. The products of combustion, which were allowed to pass through the usual absorption tubes containing pumice and sulphuric acid and potash, showed that the meteorite contained nearly 5 per cent. of organic matter. In order to obtain some idea as to the nature of the carbonaceous substance present, a quantity of the rock was powdered and then digested with alcohol; on evaporation the alcoholic extract yielded a bright-yellow resin, which was readily precipitated from the alcoholic solution by water, and much resembled the kabaite of Wohler. The most curious chemical properties of the meteorite, however, are exhibited with a cold aqueous extract of the powdered rock. The filtered liquid is quite colorless, but exhales a faint odor due to an organic salt which carbonizes on evaporation to dryness, and may be burnt upon platinum foil. The aqueous extract further contains nearly 2 per cent. of mineral matter possessing properties of a novel character. Barium chloride solution gives a heavy white precipitate, which, however, is not barium sulphate. Silver nitrate gives a voluminous curdy reddish-violet precipitate, reminding one of silver chromate, but of quite a distinct and peculiar tint, and which blackens in a very few minutes in daylight. The substance which exhibits these reactions is unchanged by evaporation to dryness, and ignition to redness, readily dissolving in water again on cooling and giving the above reactions. The silver nitrate precipitate, when allowed to stand for some time undisturbed in the liquid, becomes converted into colorless but brilliantly refractive crystals, which polarize brightly between crossed Nicols under the microscope and which are insoluble in boiling water. The properties of this new substance contained in the water extract appear to approximate most closely to those of certain metallic tellurates, but the new compound appears also to differ in certain respects from those terrestrial salts.

A New Catalogue of Valuable Papers

Contained in SCIENTIFIC AMERICAN SUPPLEMENT during the past ten years, sent *free of charge* to any address. MUNN & CO., 361 Broadway, New York.

THE SCIENTIFIC AMERICAN
Architects and Builders Edition.

$2.50 a Year. Single Copies, 25 cts.

This is a Special Edition of the SCIENTIFIC AMERICAN, issued monthly—on the first day of the month. Each number contains about forty large quarto pages, equal to about two hundred ordinary book pages, forming, practically, a large and splendid **Magazine of Architecture,** richly adorned with *elegant plates in colors* and with fine engravings, illustrating the most interesting examples of modern Architectural Construction and allied subjects.

A special feature is the presentation in each number of a variety of the latest and best plans for private residences, city and country, including those of very moderate cost as well as the more expensive. Drawings in perspective and in color are given, together with full Plans, Specifications, Costs, Bills of Estimate, and Sheets of Details.

No other building paper contains so many plans, details, and specifications regularly presented as the SCIENTIFIC AMERICAN. Hundreds of dwellings have already been erected on the various plans we have issued during the past year, and many others are in process of construction.

Architects, Builders, and Owners will find this work valuable in furnishing fresh and useful suggestions. All who contemplate building or improving homes, or erecting structures of any kind, have before them in this work an almost *endless series of the latest and best examples* from which to make selections, thus saving time and money.

Many other subjects, including Sewerage, Piping, Lighting, Warming, Ventilating, Decorating, Laying out of Grounds, etc., are illustrated. An extensive Compendium of Manufacturers' Announcements is also given, in which the most reliable and approved Building Materials, Goods, Machines, Tools, and Appliances are described and illustrated, with addresses of the makers, etc.

The fullness, richness, cheapness, and convenience of this work have won for it the **Largest Circulation** of any Architectural publication in the world.

A Catalogue of valuable books on Architecture, Building, Carpentry, Masonry, Heating, Warming, Lighting, Ventilation, and all branches of industry pertaining to the art of Building, is supplied free of charge, sent to any address.

MUNN & CO., Publishers,
361 Broadway, New York.

Building Plans and Specifications.

In connection with the publication of the BUILDING EDITION of the SCIENTIFIC AMERICAN, Messrs. Munn & Co. furnish plans and specifications for buildings of every kind, including Churches, Schools, Stores, Dwellings, Carriage Houses, Barns, etc.

In this work they are assisted by able and experienced architects. Full plans, details, and specifications for the various buildings illustrated in this paper can be supplied.

Those who contemplate building, or who wish to alter, improve, extend, or add to existing buildings, whether wings, porches, bay windows, or attic rooms, are invited to communicate with the undersigned. Our work extends to all parts of the country. Estimates, plans, and drawings promptly prepared. Terms moderate. Address

MUNN & CO., 361 BROADWAY, NEW YORK.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. AERONAUTICS.—The History of Aeronautics.—By Prof. W. LE CONTE STEVENS.—The early history of attempts at flight, with very interesting accounts of early balloonists and of some recent memorable voyages, forming the first installment of a Sibley College lecture.—4 illustrations 11790

II. AGRICULTURE.—Improved Hay and Straw Press.—A horse power continuous working press.—1 illustration 11795

III. ASTRONOMY.—A Singular Meteorite.—An account of a meteorite of remarkable composition which recently fell in Russia, which contained organic matter and presented interesting chemical reactions 11795
The Great Nebula in Orion.—By WILLIAM H. PICKERING.—Recent photographic work upon the nebula of Orion discussed by the director of the Harvard Observatory 11795

IV. CIVIL ENGINEERING.—The Hudson River Tunnel.—The tunnel under the Hudson, its state of progress, and probabilities of its early completion, with views of the work.—5 illustrations 11796

V. ELECTRICITY.—Electro-Automatic Regulator for Gas.—An electro-magnetic regulator for preserving a uniform pressure of gas, as shown at the Paris exposition.—1 illustration 11791
Improved Gas Battery.—By PAUL SCHARF.—An illustrated description of a battery for utilizing gases as the active agents.—3 illustrations 11793
Protective Rules Relating to Electric Lighting.—A series of rules embodying the extensive experience of the Boston Manufacturers' Mutual Fire Insurance Company.—A valuable *resume* of the actual risks due to electric lighting 11796

VI. IRRIGATION.—Surface Waters.—The legal aspect of surface waters, an article containing a great many decisions of value to all who are interested in the distribution of water from its natural sources 11793

VII. MEDICINE AND HYGIENE.—Rabies and its Preventive Treatment.—By ARMAND RUFFER.—A very elaborate treatment of this important subject, advocating a prophylactic series of measures for the eradication of this dreadful disease 11792

VIII. MISCELLANEOUS.—The Norwegian Skee, or Snow Shoe.—A very full description of this interesting device as used on the Western United States mountain regions, elevation and cross sections.—8 illustrations 11795
The Pergolese Street Skating Rink, Paris.—An artificial ice skating rink soon to be installed in Paris; a view of the freezing plant and of the rink itself.—2 illustrations 11795

IX. NAVAL ENGINEERING.—Marine Engine Governors.—By J. D. CHURCHILL.—The application of governors to sea-going ships, the work required of them and the type of instrument required to perform it 11795
Torpedo Boat with Petroleum Fuel.—A recent boat built at Sunderland, an elaborate description of her hull, machinery, internal arrangements, boilers, and all details.—21 illustrations 11795

X. TECHNOLOGY.—The Chemistry of Glass.—By Prof. GUSTAV GEHRING.—A very valuable lecture continued, giving the very last results in the production of toughened glass, with statistics and note on coloring glass and other technical points 11795

Useful Engineering Books

Manufacturers, Agriculturists, Chemists, Engineers, Mechanics, Builders, men of leisure, and professional men, of all classes, need good books in the line of their respective callings. Our post office department permits the transmission of books through the mails at very small cost. A comprehensive catalogue of useful books by different authors, on more than fifty different subjects, has recently been published, for free circulation at the office of this paper. Subjects classified with names of author. Persons desiring a copy have only to ask for it, and it will be mailed to them. Address,

MUNN & CO., 361 Broadway, New York.

PATENTS.

In connection with the **Scientific American,** Messrs. MUNN & Co. are solicitors of American and Foreign Patents, have had 42 years' experience, and now have the largest establishment in the world. Patents are obtained on the best terms.

A special notice is made in the **Scientific American** of all inventions patented through this Agency, with the name and residence of the Patentee. By the immense circulation thus given, public attention is directed to the merits of the new patent, and sales or introduction often easily effected.

Any person who has made a new discovery or invention can ascertain, free of charge, whether a patent can probably be obtained, by writing to MUNN & Co.

We also send free our Hand Book about the Patent Laws, Patents, Caveats, Trade Marks, their costs and how procured. Address

MUNN & CO.,
361 Broadway, New York.

Branch Office, 622 and 624 F St., Washington, D. C.

2, 1890.

lement.

year.

ribers in any
ix dollars a
.

NT, from the
had. Price

NT can like
sued yearly,
per, or $3.

IFIC AMER
AN SUPPL

agents, an

rs,

ork, N. Y.

.

PAG

Prof. W. LE
light, with
ome recent
Sibley Col-
.....

—A horse
.....

f a meteor-
ssia, which
hemical re-
.....

RING.—Re-
ssed by the
.....

—The tun-
abilities of
tions.....

—An elec-
ure of gas.
.....

trated de-
agents.—3
.....

series of
ton Manu-
e resume of
.....

of surface
of value to
its natural
.....

Preventive
treatment
series of
.....

Shoe.—A
ed on the
cross sec-
.....

tificial ice
e freezing
.....

—By J. D.
ships, the
equired to
.....

ilt at Sun-
y, internal
.....

GUSTAV
the very
statistics
.....

ooks

Engineers,
rofessional
ine of their
ent permits
ils at very
seful books
fferent sub-
circulation
sified with
have only
Address,

ew York.

.

merican
erican and
rience. Inc
the world.

c Ameri-
is Agency,
e. By the
ttention is
d sales of

or inven-
r a patent
NN & Co.
he Patent
costs and

York.

c.